STATE LIBRARY OF PENNSYLVANIA
3 0144 00447344 3

Digitized by the Internet Archive
in 2019 with funding from
This project is made possible by a grant from the Institute of Museum and Library Services as administered by the Pennsylvania Department of Education through the Office of Commonwealth Libraries

https://archive.org/details/vol1899reportofp00geol

GEOLOGICAL SURVEY OF CANADA

REPORTS AND MAPS

OF

INVESTIGATIONS AND SURVEYS

The publications of the Geological Survey of Canada may be ordered from :—

WM. FOSTER BROWN & CO., Montreal, Que.
C. H. THORBURN, Ottawa, Ont.
WM. TYRRELL & CO., 12 King Street, Toronto, Ont.
J. C. ALLAN & CO., Halifax, N.S.
J. A. McMILLAN, St. John, N.B.
ALEX. TAYLOR, Winnipeg, Man.
THOMSON BROS., Calgary, Alberta.
THOMSON STATIONERY CO., Vancouver, B.C.
T. N. HIBBEN & CO., Victoria, B.C.

ALSO THROUGH

EDWARD STANFORD, 12, 13, 14, Long Acre, London, W.C.
SAMSON LOW & CO., 188 Fleet Street, London.
F. A. BROCKHAUS, Leipsic.
LEMCKE & BUECHNER, 812 Broadway, New York.
THE SCIENTIFIC PUBLISHING CO., 253 Broadway, New York.

Price of Volume XII and of the separate reports comprised in it :

Vol. XII (with maps), 80 cents. Parts A, B and C, 10 cents each. Part G, 15 cents. Parts I and J, 25 cents. Parts M and O, 15 cents each. Parts R and S, 10 cents.

GEOLOGICAL SURVEY OF CANADA

ROBERT BELL, M.D., Sc.D. (CANTAB.), LL.D., F.R.S.

ANNUAL REPORT

(NEW SERIES)

VOLUME XII

REPORTS A, B, C, G, I, J, M, O, R, S.

1899

OTTAWA
PRINTED BY S. E. DAWSON, PRINTER TO THE KING'S
MOST EXCELLENT MAJESTY
1902

No. 782

To the Honourable
CLIFFORD SIFTON, M.P.,
Minister of the Interior.

SIR,—I have the honour to submit Volume XII (New Series) of the Reports of the Geological Survey of Canada.

The volume comprises 972 pages. It is accompanied by eight maps and thirteen plans and is illustrated by twenty-nine plates, besides a number of figures in the text.

The several parts composing the volume have been issued previously, as completed, and may be purchased separately at the prices noted on page ii.

I have the honour to be, Sir,
Your obedient servant,

ROBERT BELL,
Acting Director.

OTTAWA, 25th September, 1902.

4354

PENNSYLVANIA
STATE LIBRARY

TABLE OF CONTENTS

REPORT A.

SUMMARY REPORT OF THE GEOLOGICAL SURVEY DEPARTMENT FOR THE YEAR 1899, BY THE DIRECTOR.

	(A) PAGE.
Nature of this Report	3
Publications issued	3
Minerals and ores inquired for	5
Work connected with Paris exhibition	5
Work of the Director	7
Work proposed on iron ore district of Western Ontario	7
Necessity for new museum building	8
Additions to ethnological collection	9
Synopsis of field work	10
Experimental borings in Northern Alberta	11
Table showing equivalency of cretaceous rocks	14
Explorations and Surveys—	
Yukon district: The Klondike region, topography	16
Geology	18
Description of creeks	30
British Columbia—	
Atlin district	52
West Kootenay district	75
East Kootenay district	87
Mackenzie district	103
Saskatchewan district	110
Ontario—	
Rainy River district	115
Haliburton map-sheet	122
Eastern Ontario	131
Quebec—Shefford mountain	138
Hudson Bay—East coast	139
New Brunswick—Surface geology	148
Nova Scotia—	
Springhill coal-field	162
Gold districts	168
Cape Breton Island, Cambrian rocks	187
Museum and Office Work—	
Chemistry and Mineralogy	189
Contributions to museum	191
Mineral Statistics and Mines	197
Palæontology and Zoology	198
Natural History	209
Maps constructed and published	219
Library, Visitors, Staff, Appropriations, &c	223

REPORT B.

ON THE ATLIN MINING DISTRICT, BRITISH COLUMBIA, BY J. C. GWILLIM.

(B.)

PAGE.

Introduction and history of the district 5
Accessibility 6
Topography 7
Lakes and principal rivers 7
Terraces 10
Climate, fauna and flora 11
Glaciation 13
General geology 15
The Gold Series 18
Magnesite 21
Sandstones, conglomerates, &c 23
Granites 26
Porphyrites, andesites and basalts 28
Granite porphyry 29
Recent eruptives 30
Pre-glacial gravels 32
Origin and output of placer gold 34
Post glacial channels 35
Description of creeks 37
Quartz and lode minning 44
Water analysis 46
Map of the district 48

REPORT C.

ON THE TOPOGRAPHY AND GEOLOGY OF GREAT BEAR LAKE AND THENCE TO GREAT SLAVE LAKE BY J. MACINTOSH BELL.

(C.)

PAGE.

Route traversed and topography 5
Trip to Coppermine river 14
Fort Confidence to Great Slave lake 16
Geology 24

APPENDIX.

DESCRIPTIONS OF ROCKS COLLECTED IN 1900, BY A. E. BARLOW 29

REPORT G.

ON THE GEOLOGY AND NATURAL RESOURCES OF THE AREA INCLUDED IN THE MAP OF THE CITY OF OTTAWA AND VICINITY, BY R. W. ELLS.

(G.)
PAGE.

Formation represented and topography 5

Geology—

Medina shales 19
Lorraine formation 19
Utica shale 21
Trenton limestone 24
Black River limestone 26
Chazy limestone 29
Chazy shales 31
Crystalline rocks 35
Economic minerals—
Mica 37
Apatite 41
Iron ores 42
Barite and felspar 43
Strontianite 44
Building materials 45
Mineral waters and brick clays 48

APPENDIX.

PRELIMINARY LISTS OF ORGANIC REMAINS, BY H. M. AMI 51

REPORT I.

ON THE IRON ORE DEPOSITS ALONG THE KINGSTON AND PEMBROKE RAILWAY IN EASTERN ONTARIO, BY ELFRIC DREW INGALL.

(I.)
PAGE.

Introduction 5
General features of the district 7
Magnetite deposits, descriptions of mines 20
Hæmatite deposits, descriptions of mines 69
Other localities 79

APPENDIX A.

MICROSCOPIC EXAMINATION OF ROCKS, BY A. E. BARLOW 81

REPORT J.

ON THE GEOLOGY OF ARGENTEUIL, OTTAWA AND PART OF PONTIAC COUNTIES, PROVINCE OF QUEBEC, AND PORTIONS OF CARLETON, RUSSELL AND PRESCOTT COUNTIES, PROVINCE OF ONTARIO

BY R. W. ELLS.

(J.)
PAGE.

Introduction 5
Country north of the Ottawa river 16
District between the Rouge and North rivers 17
Area between the Rouge and Nation rivers 32
Area between the Nation and Lièvre rivers 47
The Lièvre river 53
Area between the Lièvre and the Gatineau rivers 59
The Upper Gatineau 67
Hull, Buckingham and Wakefield district 72
Sedimentary deposits in the Ottawa valley 76
Potsdam sandstone 79
Calciferous formation 81
Chazy formation 84
Black River limestone 86
Trenton limestone 87
Utica shale 88
Surface geology 90
Economic minerals—
Apatite 94
Asbestus 105
Graphite 107
Iron 110
Mica 111
Barite 134
Felspar 135
Building stones, ochres, peat and marl 136

APPENDIX.
LISTS OF FOSSILS, BY H. M. AMI 139

REPORT M.

ON THE SURFACE GEOLOGY SHOWN ON THE FREDERICTON AND ANDOVER QUARTER-SHEET MAPS, NEW BRUNSWICK, BY R. CHALMERS.

	(M.) PAGE.
Introduction	5
Physiography	6
Rivers and lakes	8
Changes and level	15
Denudation	16
Glacial striation and list of striae	17
Boulder-clay, moranies, eskers, boulders, &c	26
Eskers or osars, kames, &c	27
Remarks on the glaciation	28
Modified inland deposits	29
River and lake terraces	30
Relation of the inland stratified deposits to those of marine origin along the coast	31
Fresh-water deposits of the recent period	33
Peat bogs	34
Agricultural capabilities of the area	34
Forests	37
Economic minerals and materials	40

REPORT O.

ON CERTAIN ARCHÆAN ROCKS OF THE OTTAWA VALLEY, BY A. OSANN.

	(O.) PAGE.
Gneisses from the neighbourhood of Ottawa	3
Apatite and mica north of Ottawa	11
The vein minerals	27
Unaltered rocks, in part not scapolitised	39
Secondary pyroxenites	46
Altered plutonic rocks and pyroxenites in part	50
Crystalline schists from the apatite region	52
Eruptive rocks near the apatite veins	56
On the Eozoon limestone of Côte St. Pierre	60
Two Canadian occurrences of Graphite—	
Graphite city, township of Buckingham	66
Grenville township	73
Literature consulted	82

REPORT R.

SECTION OF CHEMISTRY AND MINERALOGY BY G. C. HOFFMANN.

(R.)
PAGE.

Miscellaneous Minerals 11
Mineralogical Notes 18
Coals and Lignites 25
Limestones and Dolomites 31
Iron Ores 35
Nickel and Cobalt 37
Gold and Silver, Assays of specimens from the—
Province of New Brunswick 38
Province of Quebec 39
Ungava district, North-east Territory 39
Province of Ontario 42
North-west Territory 43
Province of British Columbia 46
Natural Waters 48
Miscellaneous Examinations 60

REPORT S.

SECTION OF MINERAL STATISTICS AND MINES, ANNUAL REPORT FOR 1899, BY E. D. INGALL.

(S.)
PAGE.

Explanatory notes 5
Introduction 7
Summary of Production 8
" of Exports 10
" of Imports 11
Abrasive materials 11
Asbestus 17
Chromite 19
Coal 20
Coke 35
Copper 37
Graphite 45
Gypsum 47
Iron 51
Lead 71
Manganese 77
Mercury 79
Mica 80
Mineral Pigments 81

PAGE.
Mineral Water ... 84
Natural Gas ... 86
Nickel ... 86
Petroleum ... 89
Phosphate ... 95
Precious Metals—
Gold ... 97
Silver ... 108
Pyrites ... 113
Salt ... 114
Structural Materials ... 117
Miscellaneous ... 133

MAPS AND PLANS.

VOLUME XII.

*688. Yukon—Klondike Gold Fields. (Preliminary edition) ... A
*742. British Columbia.—Geological map of Atlin mining district ... B
*771. British Columbia.—Geological and topographical map of East Kootenay district (Preliminary edition) ...
*626. Ontario—Map showing the occurrences of Iron ores and other minerals in portions of the counties of Frontenac, Lanark, Renfrew and Leeds ... I
*714. Ontario and Quebec.—Geological map of the City of Ottawa and vicinity ... G
*750. Ontario and Quebec.—Surface Geology sheet No. 1, N.W. (Grenville sheet) ... J
*696. New Brunswick.—Surface Geology sheet No. 2, S. W. (Andover sheet) ... 41 M
*697. New Brunswick.—Geological Sheet No. 121. (Fredericton Sheet) ... 20 M
726. Plan of Bedford or Glendower mine, Frontenac county, O ... 20 I
727. Plan of Robertsville and Mary mines, Frontenac county, O ... 30 I
728. Plan of Fournier mine, Lanark county, O ... 34 I
729. Plan of Christie Lake mine, Lanark county, O ... 38 I
730. Plan of Wilbur mine, Lanark county, O ... 46 I
731. Plan of Yuill mine, Lanark county, O ... 54 I
732. Plan of Bluff Point mine, Renfrew county, O ... 56 I
733. Plan of Calabogie mine, Renfrew county, O. ... 58 I
734. Plan of Culhane mine, Renfrew county, O ... 62 I
735. Plan of Black Bay or Williams mine, Renfrew county, O ... 64 I
736. Plan of Chaffey and Mathews mines, Leeds county, O ... 66 I
737. Plan of Playfair or Dalhousie mine, Lanark county, O ... 70 I
738. Plan of Dog Lake hæmatite mine, Frontenac county, O ... 76 I

* *In portfolio accompanying this volume.*

PLATES.

Pine creek—Atlin gold field, B.C. ..... 1 B
Claim 93, below Discovery, on Spruce creek, B.C. ..... 32 B
Claims 2 and 3, below Discovery, Boulder creek, B.C. ..... 42 B
Claim 37, above Discovery, Wright creek, B.C. ..... 42 B
East of Atlin town site, B.C. ..... 46 B
Anticline in Chazy—Hogs Back, Rideau river, O. ..... 1 G
Marls, gravel and sand in cliff, Hemlock lake, Ottawa, O. ..... 12 G
Section in sand dune, Rideauville, Ottawa, O. ..... 12 G
Utica shale—Old Rifle Range, Ottawa, O. ..... 22 G
Trenton limestone—Foot of Parliament Hill, Ottawa, O. ..... 22 G
Trenton limestone—Table Rock, Chaudière falls, Ottawa river. ..... 24 G
Black River limestone, near Beechwood cemetery, Ottawa, O. ..... 28 G
Chazy shale and sandstone in excavation at Britannia point, Nepean township, Carleton county, O. ..... 28 G
Contorted gneiss, near ferry landing, opposite Montebello, Alfred township, Prescott county, O. ..... 1 J
Limestone conglomerate, Grenville township, Argenteuil county, Q. ..... 24 J
Contorted gneiss, near ferry landing, opposite Montebello, Alfred township, Prescott county, O. ..... 36 J
Contorted limestone, shore of Ottawa river, Papineauville, Q. ..... 39 J
Devil's play ground, Rigaud mountain, Q. ..... 93 J
I. Apatite crystals in coarse spathic calcite—Vavasour mine. ..... 84 O
II. Augite-crystal encrusted with apatite in coarsely crystalline calcite. ..... 84 O
III. Pyroxene apatite "pyroxenite"—Union mine. ..... 84 O
IV. "Pyroxenite"—Vasavour mine. ..... 84 O
V. Leopard Granite ..... 84 O
VI. Stringer of Columnar Graphite in Pegmatite. ..... 84 O
VII. Graphite stringers in granular gneiss from a graphite vein. ..... 84 O
VIII. 1. Scapolite gabbro. Vavasour mine. 2. Lime silicate-hornfels. ..... 84 O
IX. Graphite gneiss from main pit, Graphite city. ..... 84 O
X. 1. Pyroxene from scapolite gabbro. Vavasour mine.—2. Quartzite from Squaw Hill mine.—3. Phlogopite with inclusions, North Star mine.—4. Scapolite with inclusions. ..... 84 O
XI. 1, 2. Plagioclase with granophyric corrosion vein.—3. Scapolite pyroxene, Côte St. Pierre.—4. Scapolite spherulite, contact rock, Côte St. Pierre. ..... 84 O

GEOLOGICAL SURVEY OF CANADA

G. M. DAWSON, C.M.G., LL.D., F.R.S., DIRECTOR.

SUMMARY REPORT

ON THE

OPERATIONS OF THE GEOLOGICAL SURVEY

FOR THE YEAR 1899

BY

THE DIRECTOR

OTTAWA

PRINTED BY S. E. DAWSON, PRINTER TO THE QUEEN'S MOST EXCELLENT MAJESTY

1900

No. 691.

SUMMARY REPORT

ON THE

OPERATIONS OF THE GEOLOGICAL SURVEY

FOR THE YEAR 1899.

OTTAWA, January 20, 1900.

The Honourable CLIFFORD SIFTON, M.P.,
Minister of the Interior.

SIR,—As required by the Act relating to the Geological Survey Department, I have the honour to submit this the Annual Summary Report, giving an account of the condition and work of the Survey during the calendar year 1899.

Character of information given in this report.

It has in late years been found advantageous to increase the length of some of the reports included in this Summary, in order to afford a prompt means of publication of the more important results, particularly of those accruing from field-work and exploration. This, in a measure, meets the demands made for early information in regard to districts in which the staff of the Survey is known to be engaged, although several years of work are generally necessary for the complete examination of any particular area, and time is also required for the study of specimens collected and the compilation and engraving of suitable maps. This Summary Report also gives an annual statement of the executive work of the department.

Contents of last Annual Volume.

Volume X of the new series of Annual Reports of the Geological Survey (English Edition) was completed for issue before the close of the year. The edition in French is still in progress at the Printing Bureau. The volume, as issued, comprises 1,046 pages, with numerous illustrations, and is accompanied by eight maps.

The reports included in this volume, each of which had previously been issued separately, are as follows :—

Summary Report of the Geological Survey Department for 1897, by the Director.

On the Geology of the Area covered by the Seine River and Shebandowan map-sheets by W. McInnes.

Report on the Area covered by the Nipissing and Temiscaming, map sheets by A. E. Barlow.

Report on the Surface Geology and Auriferous Deposits of South-eastern Quebec, by R. Chalmers.

The Mineral Resources of the province of New Brunswick, by L. W. Bailey.

Report of the Section of Mineral Statistics and Mines, by E. D. Ingall.

Progress of Volume XI.

Of the report by Professor Bailey, on the Mineral Resources of New Brunswick, a special edition was struck off and supplied to the government of that province, at the expense of paper and press-work.

The printing of part of Volume XI (new series) is in progress, and the manuscripts of most of the reports which will be included in that volume are in hand, while some of the maps intended to accompany it are ready. It may be explained that, in the case of such maps completed before the reports to accompany them can be printed, the maps themselves are not withheld from the public, but may be obtained by any one requiring them at the usual nominal rate of ten cents per sheet. A very considerable number, for instance, of the completed plans of gold districts in Nova Scotia have thus been issued to meet immediate requirements, brought about by the recent mining developments in connection with the auriferous veins of that province.

Other publications.

The preliminary statistical abstract of the mineral production of Canada in 1898 was completed for issue on February 21, 1899.

In the palæontological series of publications, Part 1 of Volume IV, *Contributions to Canadian Palæontology*, by Mr. L. M. Lambe, has been completed and printed, while the plates for Part 4, Volume I of *Mesozoic Fossils*, by Mr. J. F. Whiteaves, have been struck off and the MS. of the text is in the printer's hands.

The printing of the first part of a systematic *Catalogue of Canadian Birds*, by Professor J. Macoun, is well advanced toward completion, and this should now soon be ready for issue.

In connection with the issue of three revised map-sheets of the Sydney coal-field in Cape Breton, a short descriptive pamphlet has been compiled by Mr. H. Fletcher, and is at the present moment in press.

Maps printed.

During the year 1899, fourteen maps have been completed and printed. These, together with those in process of engraving or compilation, are enumerated in the report of the Chief Draughtsman on a later page.

Correspondence.

The correspondence dealt with in my own office has, during the past five years, more than doubled in volume, a result largely due to the increasing interest taken in mining and related industries in all parts of Canada. Many of the inquiries received require more or less

reference or examination in order that they may be suitably answered, and this occupies a good deal of time in the aggregate. It is, however, one of the most direct ways in which the information gained by the Survey may be usefully applied, whether in regard to questions of a purely technical character, or merely in the way of placing producers and consumers of various mineral substances in communication.

Minerals and ores inquired for.

The following are among the ores and minerals that have been particularly inquired for by intending purchasers during the past year, in alphabetical order:—Amber, apatite, borax and borates, corundum, chromic iron ore, chalk, clays for various purposes, dolomite or magnesian limestones (chiefly for use in wood-pulp manufacture), felspar, graphite or plumbago, hæmatite ores free from sulphur, limestone (pure, for the manufacture of calcium carbide), magnetic iron sands, magnetite, manganese ores, marbles, molybdenite, nickel ores, ochre, onyx, petroleum, platinum, peat deposits, pyrites (iron or copper, for use as sulphur ore), sand for glass making, shell marls, soapstone, vanadium, wolframite.

In addition to the above, there has been much general inquiry in regard to iron ores and copper ores of all classes, consequent on the high prices ruling for those metals, as well as with reference to gold, silver and zinc deposits.

Work connected with Paris exhibition.

Preparations for the representation of the mineral products of Canada at the forthcoming exhibition in Paris have necessarily occupied much of my own time during the past year. It had been decided that the Canadian exhibit, in whatever lines, should be given a general or Dominion character; the very limited amount of available space, apart from other considerations, rendering it undesirable, if not impossible, to contemplate the separate participation of the several provinces as such in this international event. The restricted space accorded to the geological, mining and metallurgical exhibits, also rendered it apparent that it would be unwise to attempt to give the prominence to the scientific side of the work of the Geological Survey that has usually been possible in previous exhibitions, where palæontological, lithological and natural history collections have been displayed and recognized by awards and honorary mention. It was in fact determined, at an early date, to confine the representation of Canada almost entirely to an adequate display of the economic minerals of the country.

Exhibit purely economic.

Collection representing Canada as a whole.

Having been appointed one of the Exhibition Commissioners for Canada, and particularly charged with the organization of the exhibit in the above-mentioned classes (included under Group XI of the official general classification), I at once entered into correspondence with the provincial authorities with the object of securing their active sympathy

and coöperation in the work in hand. In some cases there appeared to be a very distinct feeling in favour of a provincial representation, or even for the representation of certain regions or mining districts separately. Appropriate as such a local arrangement might be in any exhibition held within the limits of Canada, it was felt that in going to a foreign country Canada should appear as a whole. This is particularly the case in regard to mineral products and mines, for it is to Canada as a whole that we may hope to attract capital, and in regard to which confidence may be induced. Subordinate to this general aspect the several districts and 'camps,' with their respective products, more or less distinct in conditions and nature and characterized by their differences, afford a second line of classification, leading the enquirer interested in coal, iron, copper or any other product to the particular places in Canada where it is worked or known to exist.

Coöperation of provincial authorities.

After some little discussion of the above and other considerations bearing upon the general plan of exhibition of mineral products, no difficulty was met with in obtaining the coöperation of the provincial authorities, and the Mining Bureaus of British Columbia, Ontario and Nova Scotia have particularly exerted themselves to procure and furnish suitable specimens of economic minerals. Where gaps in the general representation appeared likely to occur, special measures have been taken directly by the Geological Survey, and the resulting collection—already for the most part on its way to Paris —will, it is believed, prove to be the most complete of its kind ever prepared by Canada for any international exhibition.

Specimens dealt with and catalogued at Ottawa.

All the collections have been forwarded to Ottawa for arrangement, cataloguing and repacking, or have been examined and sent forward from other points under the supervision of the Survey. Mr. C. W. Willmott has been particularly efficient and painstaking in this work, to which he was detailed. A descriptive catalogue of the

Special exhibition publications.

Canadian mineral exhibits as a whole is in course of preparation under the supervision of Mr. E. D. Ingall, and it is intended to print large editions of this both in English and French for use and distribution during the exhibition. It is likewise intended to print a special edition of the detailed report of the section of Mineral Statistics and Mines for the purpose of the exhibition. Special editions of one or more of the provincial reports have also been promised, and previous issues of these reports as well as of the reports and maps of the Geological Survey will be sent to Paris for purposes of reference.

The number of Canadian entries under Group XI, at the present time exceeds one thousand, and to this considerable additions are likely to be made before the date of opening of the exhibition.

Director's visits of inspection in the field.

The above-mentioned work in connection with the preparation of the collection for Paris, involving correspondence with all parts of the Dominion, rendered it more than usually difficult for me to devote any considerable time to inspection or examination of work going on in the field. During the autumn, however, a few days were spent with Dr. Adams and Mr. Barlow, in that part of Central Ontario where they have been engaged for several seasons in determining and mapping the relations of the old crystalline rocks—more particularly those of the Hastings and Grenville series. The field-work necessary for the map and report on this district is now nearly completed. It is being elaborated, so far as possible, as a typical district, and interesting and important results have been developed, as explained by Messrs. Adams and Barlow on a later page of this report.

A short time was also given, at a later date, in company with Mr. W. McInnes, to the inspection, of the contacts in the vicinity of Thunder Bay of the Animikie formation with the older Keewatin (Huronian) and Laurentian rocks of that vicinity. This is a crucial question from a classificatory point of view, and the facts noted by us are entirely confirmatory of the observations already made by Dr. Selwyn and originally by Sir William Logan, leaving no room for doubt as to the entire unconformity of the Animikie upon the Keewatin schists and foliated granitic rocks with which they are there associated.

Work proposed on iron ore district of Western Ontario.

The extraordinary activity manifested in the extraction of iron ores in the northern portion of Minnesota, adjacent to that district of Ontario situated to the south-west of Thunder Bay, appears to render it immediately desirable that the part of the province referred to should be subjected to a careful geological examination and properly mapped. Here, as in Michigan and Minnesota, iron ores are known to occur both in the Keewatin and Animikie rocks; those of the Matawin and Atikokan districts, upon which numerous claims have been taken up and some work of an exploring character has been done, being referable to the first-named formation. These ores are chiefly magnetites, but there seems to be some possibility that 'soft ores,' for which so great a demand now exists because of the facility of their extraction at a low cost, may yet be discovered in important quantity, particularly in association with the Animikie rocks, within the area occupied by which a number of claims have also been taken up. It is therefore proposed, during the coming season, to undertake work upon the map-sheet immediately to the south of the Shebandowan sheet, or No. 8, in the Western Ontario Series. As about half of the rectangular area of this sheet overlaps the State of Minnesota, the survey of its Canadian portion should not occupy a very long time.

Necessity for new museum building.

Since the date of the last Summary Report, no substantial progress has, unfortunately, been made toward the provision of a suitable building for a museum and offices of the Geological Survey. Preliminary plans have, however, been drawn, and the necessity for such a building has been strongly supported in the House by members of Parliament during the past session. So far no material loss has occurred, except that of a negative character arising from the impossibility of properly representing the mineral wealth of the country to the public, and particularly to the large and increasing number of mining men from all parts of the world who now visit Ottawa. The risk of the total loss of the collections of the Survey by fire, continues, however, to be excessive, and particularly in respect to the large number of type specimens contained in the collections, it is difficult to exaggerate the serious character of the situation. It must be remembered that the present unsafe building also holds the entire reserve of publications of the Survey for past years, including maps and reports, together with many thousand plans and books of field notes, all frequently in requisition for the purpose of affording information to the public. It would be a neglect of my duty as Director of the Geological Survey to fail to again point out, in the strongest possible terms, the extreme importance of the immediate provision of fire-proof and commodious quarters for the museum and offices.

National museum advocated by Sir W. Logan.

In this connection it is interesting to note that in his Report of Progress for 1851–52, Sir William Logan, under whom the Geological Survey had already been in progress for some years, writes as follows of the quarters at that time assigned to the Survey in Montreal, with its then small collection : ' The building in which the government has at present lodged the Survey, is as well calculated for the display of these various objects as any one not expressly erected as a museum can be expected to be, but some outlay would be required for fittings. It may, however, be a consideration whether a growing country like Canada could not afford to anticipate what its future importance may require in the nature of a national museum, and at some time not far distant, erect an appropriate edifice especially planned for the purpose.'

Forty-seven years have passed since this was written, but the objection then outlined by Logan has not yet been attained. It is to the credit of Canada that the current work of the Survey has never since its inception been absolutely interrupted by the failure of financial support ; but the accumulated results of this work, both of a scientific and practical kind, have been increasing from year to year, and it would indeed be unfortunate if these should eventually be lost to the country.

Mr. B. E. Walker on Canadian museums.

Mr. B. E. Walker, in his late address as president of the Canadian Institute at Toronto, has directed attention in a very forcible way to the requirements of Canada in the matter of explorations, surveys and museums, from a strictly practical point of view. His remarks on the last-mentioned point may appropriately be quoted here. He says:—

'The Dominion Government at Ottawa and each province, at its city of chief importance, should have a museum belonging to and supported by the people. These museums should contain exhibits of the metallic and non-metallic minerals of the country, both those of economic and of merely scientific value, the forest trees, with the bark preserved, in say six feet sections, cut also and partly polished, and each specimen accompanied by a small map showing its habitat; the fresh water and sea-fishes mounted after the modern methods; the fur-bearing animals, the game birds and the birds of our forests, fields and sea-coast, many of them mounted so as to tell a child their habits at a glance; the reptiles, crustaceans, insects, plants, indeed as complete a record of the fauna and flora of the country as possible; the rocks of stratigraphic importance and all the varieties of fossils which can be gathered in this country; the archæological and ethonological evidences of the races we have supplanted in Canada, and much more that does not occur to me at the moment. I should not like to suggest a limit of expenditure on such museums. The necessity of a new building at Ottawa is admitted. The crime of leaving exposed to fire, in a wretched building never intended to protect anything of value, the precious results of over fifty years of collecting, has been pointed out in a recent official report. . . . . .
I can only repeat that we are rich enough to bear the cost with ease, but we are not intelligent enough to see our own interest in spending the money.'

Additions to ethnological collection.

Several rather important additions have been made to the ethnological collections during the year, chief among which is the acquisition of the Aaronson collection by purchase. This collection comprises over 500 objects, many of them old and rare, derived from the Indian tribes inhabiting the coast of British Columbia. There is not sufficient space to display these in the present condition of the Museum, but the opportunities of obtaining such valuable material are so fast passing away that it was thought desirable to acquire this collection, even if it must for the present be merely stored. Dr. C. F. Newcombe, of Victoria, kindly supervised the listing, checking and packing of the collection. We are also indebted to Dr. Newcombe and to Mr. C. Hill-Tout for frequent assistance in connection with specimens of the kind from British Columbia.

Field-work.

The number and distribution of the field parties employed during the past summer, may be stated as below :—

British Columbia	3
Yukon District	1
Great Slave Lake	1
Alberta (boring operations)	1
Saskatchewan	1
Ontario	3
Ontario and Quebec	1
New Brunswick	2
Nova Scotia	2
Ungava (East coast of Hudson Bay)	1
	16

Special examinations in the field.

In addition to the above-mentioned parties occupied in the field during the greater part of the season, special examinations or inquiries were carried out by other members of the staff. Dr. Ami continued palæontological investigations in parts of Nova Scotia and New Brunswick. Mr. Willimott visited a number of places for the purpose of obtaining specimens for the Paris Exhibition ; Mr. Denis spent some weeks in inquiring into recent developments of the oil and gas fields of Ontario, and Prof. Macoun visited Sable Island.

By Professor Osann.

Professor A. Osann, of Mülhausen, Germany, the distinguished petrographer with whom some correspondence had been carried on in regard to petrographic work, having volunteered to carry out some such work on terms very advantageous to the Survey, arrangements were made for this and Dr. Ells and Mr. Ingall accompanied him in the field for several weeks. The special problem to which Professor Osann directed his attention while in Canada, was the nature of the rocks associated with the apatite and graphite deposits found in that part of Quebec north of the Ottawa River. Large suites of specimens were collected, of which sections for microscopical study are now being made, and the report which Professor Osann is to furnish upon this work will be awaited with much interest.

By Dr. Matthew.

Dr. G. F. Matthew of St. John, New Brunswick, who has long devoted himself to the study of the older faunas, and particularly to that of the Cambrian in eastern Canada, was induced to undertake for the Survey an examination of the Cambrian of Cape Breton Island. A short preliminary report of Dr. Matthew's is given on a later page.

By Professor Dresser

The Survey is also indebted to Professor J. A. Dresser, of Richmond, Quebec, who has continued his petrographic examination of Shefford Mountain. A statement in regard to this work is given further on,

and it appears that it may now be possible to complete a detailed report upon this limited area which presents some features of particular interest.

Experimental Borings in Northern Alberta.

Boring operations were resumed early in the summer at Victoria, on the Saskatchewan, where a depth of 1,650 feet had been attained when work stopped in the autumn of 1898. It was anticipated that a depth of some 2,000 feet would have to be reached at this place before the possibly petroleum-bearing strata of the base of the Cretaceous formation would be penetrated and tested. From the report of Mr. W. A. Fraser, the contractor for the work, given below, it will be found that it proved impossible to carry the boring beyond 1840 feet. Operations were then suspended, and after extracting as much of the casing from the hole as possible and storing this and other Government property, the contractor and his men returned.

Boring operations for petroleum.

As explained in previous Summary Reports, the difficulties met with in carrying out these experimental borings have proved to be exceptionally great. To this there are several contributary circumstances, but the principal one is the generally soft and incoherent character of the great mass of the overlying Cretaceous rocks to be penetrated. This renders it necessary to case every bore-hole throughout and to carry down the casing *pari passu* with the drill. When casing of any particular diameter can be driven no further, another and smaller one requires to be provided, and the liability to accidental stoppage of the casing is so serious that the only certain means of attaining great depths would consist in beginning with a bore-hole and casing of very large diameter. This, of course, would imply greatly increased cost.

Exceptional difficulties met with.

The first boring was that undertaken at Athabasca Landing, and this was carried to a depth of 1,770 feet, when it had to be abandoned without actually reaching the basal beds of the Cretaceous formation. Following this, a boring was put down on the Athabasca near the mouth of the Pelican River, about ninety miles down-stream from the Landing. The thickness of the overlying beds was here known to be much less and the boring reached a total depth of 837 feet, actually penetrating in part the lower beds of the Cretaceous and revealing the presence of a thick petroleum or maltha, together with that of a great quantity of natural gas. The gas rendered it impossible to prosecute this boring further. The third boring, that at Victoria, has already been referred to above.

Resumé of borings carried out.

For particulars in regard to the borings and general conditions of occurrence of the great quantities of tar or maltha in the lower rocks of the Cretaceous in the Athabasca region, (believed to indicate the existence of an important oil-field) reference may be made to previous

Indications still favourable.

Summary Reports, and particularly to that for 1898. It may here be repeated, however, that the failure in two cases to actually test the lower beds of the Cretaceous which were sought, has not in any way decreased the probability of ultimate important developments in this great northern region. The information gained in regard to the thickness, character and continuity of the strata is of much value and such as to materially assist in further operations, which will undoubtedly be undertaken in the near future.

Summary of results attained.

In the present condition of the work, it appears to be of interest to bring together, in a generalized form, the sections found in the several bore-holes which have been given in detail, as operations progressed, in previous reports.

With the assistance of Mr. R. G. McConnell, the driller's log of the Victoria borings, as well as the entire suite of specimens accompanying it, have been carefully examined and compared with his measured section on the Athabasca River, and with the logs of the borings at Athabasca Landing and Pelican River. In the accompanying table an attempt is made to show, in comparative form, the equivalency and thickness of the formations penetrated in the several bore-holes. The Athabasca River section will be found in the Annual Report, Vol. V. (N.S.) part D. The table may also be compared with the sections given by Mr. Tyrrell and myself for parts of Alberta further to the south, in Vol. II. (N.S.) part E, and in the Report of Progress, 1882-84, pp. 112c to 118c.

Comparison of sections in borings.

The section met with in the Victoria bore-hole is evidently intermediate in character between that of the Athabasca and that of Southern Alberta, but more closely corresponds with the former. The Belly River brackish-water and fresh-water formation that forms so important an intercalation at or about the base of the Pierre proper in the south, cannot here be recognized. The lacustrine or estuarine conditions producing it have, apparently, not extended so far to the north. This formation was recognized by Mr. Tyrrell on the Battle River and probably as far north as the Vermilion River, as indicated in his report above referred to and on the map accompanying it.

On the other hand, the upper part of the Victoria section seems to correspond very closely with the Pierre proper of Southern Alberta, showing, as in the Red Deer River sections, about 500 feet of brownish or 'coffee-coloured' shales at the top,* but having, apparently, in the aggregate a somewhat greater volume. It appears also to be a little thicker than the upper part of the La Biche shales assigned to the Pierre on palæontological grounds by Mr. McConnell.

* Report of Progress, Geol. Surv. Can., 1882-84, p. 115c.

In the sections on the Athabasca, including the borings at Athabasca Landing and Pelican River, the persistence of the Pelican and Grand Rapids sandstones render it possible to fix equivalency of horizons with considerable accuracy, but neither of these sandstone intercalations occur in recognizable form at Victoria, and it does not appear to be possible to draw any line of demarcation until a depth of about 1,500 feet is reached, at which depth it seems probable that beds representing the Grand Rapids sandstones may be entered. The assignment of beds made to this formation, however, as well as that in the case of the underlying Clearwater shales, can not be accepted as at all definite. It is based on such indications as the specimens afford, together with a consideration of the relative thickness of the shaly beds met with, which, it may be assumed, is probably pretty constant in this region at places not very remote from each other. Equivalency fixed with difficulty Victoria

From all the evidence now available, it would appear that the Victoria bore-hole penetrated to within about 250 feet of the top of the 'Tar-sands,' should these occur here, this horizon being at a depth of about 2,100 feet from the surface. At Athabasca Landing the bore-hole probably reached to within a very few feet of the top of the 'Tar-sands,' which may there occur at a depth of about 1,800 feet. At the Pelican River the same horizon was reached, nearly as anticipated, at 750 feet from the surface, and the 'Tar-sands' were penetrated for a further depth of eighty-seven feet before the gas and tar necessitated the abandonment of the work. Horizons at which boring terminated.

The depths above given may practically be considered as measured from the water-levels of the Saskatchewan and Athabasca rivers at the places mentioned, as all the borings began on low river-flats.

The thickness of the 'Tar-sands' where measured in natural exposures by Mr. McConnell, further down the Athabasca, varied from 140 to 220 feet. Had it been possible to do so, the attempt would have been made not only to traverse this formation, but to penetrate the Devonian limestone which is supposed continuously to underlie it, as it is no doubt from these Devonian rocks that the petroleum or maltha accumulated in the 'Tar-sands' has originally been derived. Probable source of oil

On the right-hand margin of the table, the probable equivalency of the formations met with in the borings with those recognized to the south and south-east is indicated. The reference of the several lower formations to the Dakota, depends upon observations made on the Athabasca River by Mr. J. B. Tyrrell, in accordance with which the Grand Rapids sandstones, Clearwater shales and 'Tar-sands' appear to represent a marine formation of that period with a nearly homogeneous fauna.* The Belly River formation is, as above indicated, Comparison of sections with others.

* Ottawa Naturalist, May, 1898.

probably represented by shales of marine origin, but these do not appear to show the highly calcareous character of the typical Niobrara group, as recognized in parts of Manitoba and in the region to the south of that province, although the Belly River and Niobrara are undoubtedly, in part at least, contemporaneous.

The table here given will, it is believed, serve as a useful reference in connection with further boring operations.

Report on Victoria bore-hole.

Mr. W. A. Fraser's report upon the operations at Victoria is as follows :—

'Boring operations at Victoria had ceased in the fall of 1898 with the sudden stopping of the $4\frac{5}{8}$ inch casing at a depth of 1,650 feet.

'It was thought that by introducing 4 inch casing into the boring it might be carried on down to the desired depth of 2,000 feet or more. To this end the necessary casing was purchased, the 4 inch tools brought up from Pelican River, and improved patent under-reaming bits obtained for these small tools. A very efficient staff was engaged, including the same driller who had been in charge of the boring during the preceding season.

'As had always been the case in the different borings which had been sunk in Alberta, great caving was encountered continually. But the drilling progressed favourably up to the very day the casing became jammed so tight that it could neither be pulled up nor driven down.

'The driller was of the opinion that a piece of the hard sandstone had fallen in beside the casing and wedged it. This had occurred twice before during the season's drilling. Each time he had managed to loose the casing again without great difficulty, but this time it resisted all our efforts.

Cause of stoppage of work.

'The driller, Mr. William Slack, had been a master-driller for at least thirty years, had drilled in different foreign countries, and had great experience and a high reputation as an exceedingly skilful, careful driller. During my own twenty-three years of experience I had acquired a fair knowledge of the work, but our united efforts could not avail, assisted by the very best and latest improved machinery, to overcome that seemingly simple accident of the casing having become wedged hard and fast at a depth of 1,840 feet. We pulled on it with strong iron blocks and broke spruce logs 18 inches in diameter used as levers. We pulled to the last limit of the strength of the casing and might have pulled it in two, but that would have availed nothing; besides it would in all probability have prevented us from saving the several thousand feet of casing we eventually recovered from the bore. We also drove on it with a large sinker until we battered in the end of the top length. No blame could be attached to any one in connection with this unfortunate ending.

'I then wired to the Department at Ottawa asking for instructions. In compliance with your answer I recovered from the boring the casing as per list furnished you by me.

'At this depth, 1,840 feet, there was no indication of petroleum nor any indication of the "Tar-sands," encountered at 800 feet in the Pelican boring on the Athabasca. It appears to me probable that if the "Tar sands" exist here they are at a very great depth.

'In compliance with your instructions all the casing was carefully piled, an inventory taken and forwarded to you. All the government property other than casing, was taken to Edmonton, and stored in the Hudson's Bay Company's warehouse, and inventory also furnished to you. Casing and appliances stored.

'The work for the season has been uneventful, with the exception of the sudden stoppage of progress, so there is little of interest to chronicle.

'If further borings are to be made in that section the experience of the past may be of value. The bore-holes will need to be commenced with a very large diameter, and a higher price paid for the work in consequence. Indications for further borings.

'I append the record of strata pierced as kept by the driller in charge. It was monotonously recurrent in irregular thickness, sandstone and shale.

'These strata of hard sandstone make the drilling precarious and difficult. The soft shale caves away and leaves no supporting wall to guide the tools straight through the hard strata, and the caving clogs the bit so that the casing must constantly be kept within a few feet of the bottom.

'With that difficult formation the element of chance must always be prominent. A string of casing may be carried for a thousand feet, or it may suddenly become wedged hard and fast after it has been driven two or three hundred feet. The natural obstacles are so great that the driller or person in charge, if using his utmost endeavour to make the boring successful, should hardly be held answerable for a failure to reach the required depth. I doubt if any man in Canada would be found willing to take the risk.'

The following section, as returned by the driller, is in addition to that given in the last Summary Report, p. 36 A :— Additional depth gained in 1899.

1,650–1,665 feet, sandstone.

1,665–1,669 feet, dark shale.

1,669–1,680 feet, very hard sandstone.

1,680–1,840 feet, dark-blue shale, intersected by strata of hard sandstone, varying in thickness from one to four feet.

Yukon District.

Yukon District.

Mr. R. G. McConnell, during the summer of 1899, continued his examination of the richly auriferous territory in the Klondike division of the Yukon district. He was assisted by Mr. J. F. E. Johnston, who undertook the topographical work necessary for the mapping of the rock formations and gold-bearing gravels. Because of the amount of inquiry directed to this region, Mr. McConnell has been requested to furnish a somewhat full preliminary report upon it, which follows.*

Work by Mr. R. McConnell.

The Klondike Region.

Geography of Klondike region.

'The Klondike gold fields are situated east of the Yukon River in latitude 64° north. They are bounded in a general way by the Yukon River on the west, by the Klondike River on the north, by Flat Creek a tributary of the Klondike, and Dominion Creek, a tributary of Indian River, on the east, and by Indian River on the south. The area included between these boundaries measures about 800 square miles. The streams flowing through the area described are all gold-bearing to some extent, but only a limited number have proved remunerative. The most important gold-bearing streams are Bonanza Creek, with its famous tributary Eldorado Creek, Bear Creek and Hunker Creek flowing into the Klondike, and Quartz Creek and Dominion Creek, with Gold Run and Sulphur Creek two tributaries of the latter, flowing into Indian River. A good deal of prospecting has been done outside the area described, but with the exception of a few claims on Eureka Creek, a tributary of the Indian River from the south, no pay-gravels have so far been discovered, although good prospects are reported from many places.

Topography.

Physical features.

'The Klondike region may be described as a high plateau cut in all directions by numerous deep and wide branching valleys. The general aspect viewed from one of the higher elevations is rough and hilly but fairly regular. The outlines are rounded, the slopes even, and sharp peaks are notably absent. The region is really formed of a system of long, branching, round-backed ridges, separated by deep, wide, flat-bottomed valleys. Most of the ridges, speaking broadly, centre in the Dome, the highest eminence in the district.

'The ridges have an average elevation above the valley-bottoms of 1500 feet. They are deeply gashed on both sides by steep gulches and are surmounted by numerous bare rounded prominences separated by wide depressions. They radiate out in irregular curved lines from

* This report, in practically identical form, has already been printed in advance as a separate pamphlet.

the Dome and descend gradually, throwing off branches at intervals, towards the main water courses. Yukon District—*Cont*

'The elevation of the ridges and surmounting hills is fairly uniform. The Dome has an elevation of about 4,250 feet above the sea, 3,050 above the Yukon at Dawson and about 500 feet above the ridges at its base. It is not conspicuously higher than other hills in the neighbourhood, and the gradual decrease in elevation outwards along the ridges is scarcely noticeable to the eye. Elevations.

'The valleys are wide and flat-bottomed in their lower parts, but gradually narrow towards their heads into steep-sided narrow gulches, which terminate abruptly in steep, rounded, cirque-like depressions cut into the sides of the ridges. The valley-flats are marshy, partly wooded, and are wider on the Indian River than on the Klondike slope. The flats bordering the lower parts of Dominion Creek have a width in places of nearly half a mile. Valleys

'The streams are small, seldom exceeding 15 feet in width, even at their mouths, and along the productive portions of the valleys are much less. They fall rapidly near their heads, but in descending the valleys the grade soon diminishes, and in the case of Dominion and other Indian River creeks does not exceed, in the lower parts of the valleys, 25 feet to the mile. The Klondike streams are somewhat steeper, the grade averaging in the lower parts of the valleys about 40 feet to the mile. Streams.

'The Klondike River is a large rapid stream averaging about 150 feet in width. It is interrupted by frequent bars, and has a fall of from 12 to 15 feet to the mile. Indian River, which forms the southern boundary of the district, is a much smaller stream. It has a width of from 20 to 40 yards, but is very shallow, the water on the bars seldom exceeding a few inches in depth. The channel is filled, for long stretches, below Quartz Creek, with large angular boulders and the navigation of the stream, even with small lightly loaded boats, is very difficult. The fall of the valley from Australia Creek to the mouth averages about 18 feet to the mile. Klondike River.

Forest—

'The forest trees consist of the white and black spruces, the aspen and balsam poplars and a species of birch. No pine or fir trees were noticed. The lower ridges and the slopes of the higher ones up to a height of 3,500 feet above the sea, are generally wooded, and stunted spruces occur sparingly on the highest points in the district. The valley-flats are only partly wooded. Groves of spruce and poplar occur at intervals, but alternate with bare swamps and marshes too soft to support a forest growth. Forest.

Yukon District—*Cont.*

Spruce.

'The white spruce is the most important tree for general purposes in the district. It is usually small on the ridges, seldom exceeding a foot in diameter, but in the valley-flats occasional specimens attain a diameter of over two feet and a large proportion of the logs cut for lumber, measure from nine to fifteen inches across. The supply for the mills at Dawson is obtained mostly from the flats and islands along the upper Yukon, and from the Klondike valley and is ample for all purposes for many years to come. The Klondike is bordered at intervals all the way from its mouth to the mountains by groves and small tracts of spruce forest of surprising size and quality considering the latitude, and supplies of well grown spruce timber are also available from all the larger tributaries of the Upper Yukon as well as from the main valley, and can be easily and cheaply floated down to Dawson.

'The supply of large timber on the producing creeks themselves is limited, but the bordering ridges are nearly everywhere, except on the higher points, clothed with an open forest of small spruce, birch and poplar ranging from a few inches to a foot or more in diameter. A portion has been destroyed by forest fires, but sufficient remains to furnish all the fire-wood and most of the lumber required for mining purposes for a considerable time.

Geology.

Rock-series represented.

'The geology of the gold region is complicated and need only be briefly described here. The rocks are separable into the following divisions, none of which can, as yet, be exactly correlated with formations described in previous reports on British Columbia, the Yukon District or Alaska. The order is ascending, so far as known.

Stratified and foliated rocks, mostly Palæozoic
- Indian River series.
- Hunker series.
- Klondike series.
- Moose Hide group (in part.)

Tertiary.

Eruptive rocks
- Granites.
- Later eruptives.

Indian River series.

'*Indian River Series.*—The Indian River beds consist mainly of dark slates, often hard and quartzitic, and occasionally passing into a rock of gneissic appearance from the development of biotite along the cleavage planes. The slates are associated with bands of grayish crystalline limestones often several hundred feet across, quartzites, and toward the upper part of the formation by green schists of volcanic origin.

'The Indian River beds occur along the Yukon River from Indian River down to a point three miles below Ensley Creek, and are exposed

with few breaks along the whole course of Indian River. They strike in a direction a little south of east and dip as a rule to the north at high angles, but are irregular in this respect. Their thickness is not known. Yukon District—*Cont.*

'*Hunker Series.*—The Hunker beds are mainly lead-coloured and dark graphitic schists somewhat resembling the softer portions of the Indian River series. They include, on Hunker Creek, small bands of limestone and dolomite and some green schists. They are very irregular in their distribution and often occur in narrow, short bands folded in with the Klondike series. They are found in considerable volume along the lower part of Hunker Creek and in narrow disconnected bands crossing Bonanza, Eldorado, Dominion and other creeks of the district. Hunker series.

'*Klondike Series.*—The Klondike series is the most important group of rocks in the district, as it constitutes the country-rock along the productive portions of all the richer creeks, and is, apparently, genetically connected with the occurrence of the gold. The rocks of this series are now mainly light-coloured and greenish micaceous schists, the principal minerals present being quartz, orthoclase, some plagioclase, and sericite. The ferro-magnesian minerals are almost entirely absent. The rocks are greatly crushed and altered and in places are almost entirely recrystallized. They have not, as yet, been closely studied microscopically, but appear, with little doubt, to have originated from eruptives and in part at least to have been derived from a quartz-porphyry. On Sulphur Creek the rocks of this series pass gradually into a granitoid condition. Klondike series includes principal gold-bearing rocks.

'The principal varieties are a soft, well foliated light-grayish sericite schist, and a harder schistose rock occurring in flags and heavy beds, often sprinkled with rounded quartz blebs and occasionally with angular felspar crystals. They include also a fine-grained hard rock resembling a quartzite. In the eastern part of the district the light-coloured varieties alternate with bands of green well foliated schists, which may belong to an older period.

'The rocks of the Klondike series occur along the Yukon from the northern boundary of the Indian River series down nearly to Dawson, and extend in an easterly direction in a wide band across Bonanza and Eldorado creeks, Quartz and Sulphur creeks, and the upper parts of Hunker and Dominion creeks. They occur also on Flat Creek, further to the east, but their limits in this direction are not precisely known, as they pass east of Flat Creek below a heavy covering of gravel. The outline of the area is fairly regular, but is broken in places by occasional spurs from the central mass. Distribution.

'*Moose Hide Group.*—Under this head I have included a group of green igneous rocks which occurs in Moose Hide Mountain and other Moose Hide group.

Yukon District—*Cont.*

points along the northern border of the district. They are schistose in places, but are usually massive and range in texture from a moderately granular to a compact condition. They belong mostly to the diabase group, and have been altered more or less completely over wide areas into serpentine. The rocks included in this group belong to different periods, as some of the members, notably the fine-grained massive variety forming Leotta Mountain, are quite recent, while those at the mouth of the Klondike have a much older look and have been crushed into schists, especially around the edges of the mass. Bands of green schists of uncertain age also alternate all along the lower part of the Klondike with the dark Hunker schists and other rocks.

Distribution.

'The Moose Hide group of rocks occurs in angular and rounded areas and wide bands, distributed at intervals along the Klondike valley from its mouth easterly to Flat Creek. Rocks of this group are also found on the ridge separating Hunker Creek from the Klondike and at one point on the ridge east of Hunker.

Tertiary rocks.

'*Tertiary Beds.*—Beds referred to the Tertiary occur at several points around the outskirts of the gold district. A wide band follows the Yukon valley above Dawson, on the north-east side, and continues on in a direction a little south of east to the Klondike, which it crosses a short distance above the mouth of Rock Creek. It then follows the Klondike River to the mouth of Flat Creek, and probably underlies the belt of plateau country that borders the latter and extends through to the Stewart.

Lignite.

'Exposures of these beds on Rock Creek and the Klondike River consist mostly of soft, grayish sandstones, indurated clays and shales, and occasional beds of ironstone. A thick lignite seam is reported to outcrop on one of the branches of Rock Creek, and other seams occur along the band in its north-westerly extension. A seam, or group of seams, said to be fifteen feet in thickness, is being worked on Cliff Creek, about seventy-five miles below Dawson, for the supply of that place.

'A small area of dark sandstones, agglomerates, hardened clays and shales, was found on Last Chance Creek, a tributary of Hunker Creek, lying at angles on the schists. The sandstones contain small particles of carbonaceous matter, but no lignite was noticed.

'Tertiary beds were also found along the southern boundary of the district on Indian River. The northern limit of this area follows Indian River valley from Quartz Creek to a point above New Zealand Creek, and the band extends southward beyond the region examined. The beds lie in easy folds, and consist mainly of soft, light-grayish sandstone, dark, coarse, agglomeratic sandstone, soft, dark shales, and, at one point, of heavy beds of coarse conglomerate. Fragments of

fossil plants occur throughout the formation, but no determinable specimens were found. Yukon District—*Cont.*

'*Granites.*—A small area of granite occurs on the Yukon River below the mouth of Indian River, and stretches eastward in a band a couple of miles wide towards the head of Ensley Creek. It is a coarse-grained, grayish biotite variety, and as a rule is coarsely porphyritic. Granites.

'A large area of granite also occurs at the heads of Burnham and Australia creeks, east of Dominion Creek, and extends southward towards the Stewart. It appears to be older than the mass on the Yukon River, is very coarse-grained, often porphyritic, and in many places has been crushed into an extremely coarse augen-gneiss. Exposures of this rock occur in conspicuous crags along the crests of the ridges separating the tributaries of Dominion Creek from those of Australia Creek.

'A third area of granite extends from the mouth of Dominion Creek up to a point two miles above Sulphur Creek and also runs for some distance up the latter creek. It appears to pass gradually, going up Sulphur Creek, into the schists of the Klondike series. It is grayish in colour, medium-grained, and is of the ordinary biotite variety, with few accessory minerals. The biotite gradually disappears on approaching the schists, and is replaced by light-coloured micas, principally sericite.

'*Later Eruptives.*—Small bosses of recent eruptive rocks cutting all the older formations occur everywhere throughout the district. The principal variety is a light-grayish acid rock with a compact base, sprinkled with small dark quartz crystals, and is probably a rhyolite or closely allied rock. In some of the sections felspar phenocrysts occur with the quartz, and in other places the rock becomes granular. The areas seldom exceed a quarter of a mile in width, and are more numerous around the outskirts of the gold district than towards its centre. Small areas of later eruptives.

'A dark rock, which macroscopically appears to be an augite-andesite, occupies a small area bordering the granite below Indian River, and dark basaltic-looking dikes occur on Indian River, below the mouth of Quartz Creek. A few small trap-dikes cross Eldorado Creek, and a large quartz-porphyry dike forms a point projecting into Bonanza valley at No. 60 below Discovery claim.

'The total area covered by the later eruptives is small, but their wide distribution in small bosses and dikes makes them a conspicuous feature in the geology of the district.

'*Quartz Veins.*—Quartz veins are exceedingly abundant in the schists of the Klondike series and also occur, but more sparingly, in Quartz veins.

Yukon District—*Cont.*

the Indian River group and the Hunker schists. The veins as a rule are short and small, but often swell out into large lenticular masses of quartz. They follow in the majority of cases the planes of foliation or cut these at a low angle. A few veins were noticed cutting directly across the strike of the rocks, and these as a rule are more regular and persistent than those which follow the foliation; they may belong to a different group. In addition to the multitude of quartz veins varying in size from mere threads up to huge masses nearly a hundred feet in thickness like that on the Yukon River two miles above Caribou Creek, which follow or intersect the schists of the Klondike series, these schists themselves are often more or less silicified along wide zones, occasionally to such an extent as to resemble quartzites.

Character of quartz.

'The quartz in the smaller veins is usually milky or light-grayish in colour and often when weathered assumes a granular appearance. The veins contain occasional crystals and small patches of felspar and dolomite. The large vein above Caribou Creek has a more compact texture and weathers to a light-yellow colour.

Metallic contents.

'The principal metallic minerals of the veins are pyrite, chalcopyrite, galena (usually argentiferous) and occasionally free gold. The veins are not as a rule well mineralized and the great majority contain nothing except a few scattered grains of pyrite. A number of specimens collected in various parts of the district and analysed in the laboratory of the survey were all barren, with one exception, and that contained only traces of gold. On the other hand, a number of assays made in Dawson from different veins were seen by the writer that showed good values. There can be no question that the placer gold, like the accompanying gravels, is of local origin and is derived from the quartz veins and silicified schists of the district. The large nuggets nearly always inclose fragments of quartz, and quartz pebbles specked with gold are occasionally found. A boulder found on No. 4 Bonanza Creek, weighing 60 ounces, contained 20 ounces of gold. Evidence of the local origin of the gold is also afforded by the markedly angular and unworn character of the grains and nuggets found in the gulches and along the upper parts of the productive creeks. It is highly improbable that the gold-bearing veins have all been swept away and their metallic contents concentrated in the valleys, great as the erosion in the district has been, and there is every reason to believe that productive veins or zones of country-rock will eventually be discovered. The prospecting of the past two seasons has resulted in the staking of a great number of quartz claims, but very little development work has so far been done. Prospecting can only be carried on at present over a small portion of the district, as the country-rocks are nearly everywhere concealed beneath a heavy blanket of moss.

Connection of gold with quartz.

Gravels—

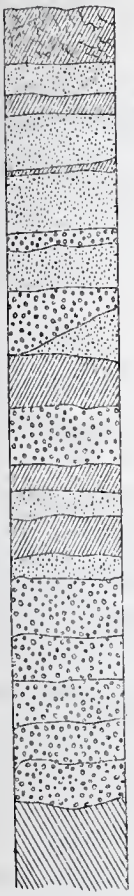
Yukon District—*Cont.*

Classification of gravels.

'The gravels of the district are of four different kinds, as follows, beginning with the latest:—

Stream-gravels (present).
Terrace-gravels.
River-gravels.
'Old valley-gravels (quartz-drift and yellow-gravels).

'The gravels are described in connection with the creeks, and with the exception of the quartz-drift will only be briefly referred to here.



Section of stream-gravels, claim 27 above Discovery, Bonanza Creek. Scale 4 ft. to 1 in.

Stream-gravels.

'*Stream Gravels.*—The stream-gravels form a sheet generally from four to ten feet in thickness, flooring the bottoms of all the valleys. They rest on broken and decomposed schists, and are overlain by a bed of dark frozen "muck" or peaty matter. They are very uniform in character, and consist entirely of the schists and other rocks of the district. In the lower parts of the valleys, the schist pebbles are usually flat, but are fairly well worn. They measure, as a rule, from one to two inches in thickness and from two to six inches in length. They lie in a matrix of coarse sand, and are associated with a varying proportion of rounded and sub-angular quartz pebbles and boulders, and, less frequently, with pebbles derived from the later eruptive rocks. Small beds of sand occasionally occur toward the top of the section, but, in most cases, the deposit is remarkably uniform from muck to bedrock. In the upper part of the valleys, the gravels become coarser and more angular, and a considerable proportion of the material consists of almost unworn fragments of country-rock washed down from the adjacent slopes.

Terrace-gravels.

'*Terrace Gravels.*—Narrow rock-cut terraces occur in an interrupted manner along Eldorado, Bonanza and Hunker creeks, below the level of the old valley, and a wider series along a portion of Dominion Creek, at an elevation of from fifteen to forty feet above the present

Yukon District—*Cont.*

flat. The terraces support beds of gravel, usually from six to fifteen feet in thickness, very similar to that in the valley-bottom, but showing somewhat more wear. They are covered in a few places with muck.

River-gravels

'*River Gravels.*—At the mouth of the Hunker and Bonanza creeks the quartz-drift is overlain by a heavy bed of well rounded pebbles, evidently representing a former wash of the Klondike River. The pebbles consist largely of hard slates, quartzites and other rocks foreign to the gold-bearing creeks. Wide terraces built of similar material also occur at the mouth of the Klondike and at intervals along the valley of that river.

Old valley-gravels.

'*Old Valley Gravels.*—These gravels, bordering parts of Bonanza, Eldorado, Hunker and other creeks of the district, consist of a deposit known as the quartz-drift, resting on bed-rock, and an upper set of flat rust-coloured gravels.

The quartz-drift.

'The quartz-drift differs markedly in many of its characters from any deposit either marine, lacustrine, fluvial or glacial, known to the writer. It is uniformly grayish to nearly white in colour throughout, except near the surface, where it has been oxidized to varying depths and in places has a reddish coloration, and in the upper portions of some of the streams, where the grayish colour becomes somewhat darker. The colour does not vary to any material extent with differences in the subjacent rock, as in many places heavy deposits of the quartz drift, looking almost white at a distance, rest on wide bands of dark graphitic schist. It consists essentially of a compact mixture of small, clear, little worn and often sharply angular quartz grains, and minute scales of sericite, thickly packed with rounded, sub-angular, and wedge-shaped boulders of quartz, and less frequently of grayish mica-schist, the principal rock of the district. The deposit is remarkably uniform from top to bottom. Beds of coarse sand were noticed, but are infrequent, and in the great majority of the sections the silicious sands and the light micaceous minerals have not been sorted into separate beds but remain intimately commingled throughout. The sands become noticeably coarser toward the limit of the deposit on the upper parts of the creeks.

Boulders in quartz-drift.

'The boulders of the quartz-drift are always more or less rounded and water-worn, and are found in all sizes from small pebbles up to boulders two and three feet in diameter. They occur scattered irregularly through the sandy matrix, or roughly stratified in it, but were nowhere found forming heavy homogeneous beds. They do not show evidence of prolonged rolling. Rounded boulders are occasionally present, but in the majority of cases the edges only are worn away, and wedge-shaped sub-angular fragments, still preserving approxi-

Generalized cross-section of Bonanza Valley below Eldorado Forks
Scale 400 feet to 1 inch

Yukon District—*Cont.*

mately the shape of the short blunt veins from which they originated, are very common. The proportion of quartz to schist boulders was estimated at fully four to one, and in some sections the ratio is even higher than this. No fragments originating from the bands of dark graphitic schists which cross the valleys at various points, were noticed.

Thickness of quartz-drift.

'The quartz-drift varies in thickness from a few feet up to about 120 feet, and in width from 300 feet to half a mile or more. The deposit is narrow near the heads of the creeks and attains its greatest development near the lower parts of Hunker and Bonanza creeks, but the increase in volume in descending the valleys is not uniform. It is piled up to great depths on Gold Hill and Adams Hill on Bonanza Creek, decreases in amount on the succeeding hills and in places is absent altogether, and, farther down, after crossing the valley, continues on to the mouth in greatly increased volume.

Overlying gravels.

'The quartz-drift is overlain in places by loosely stratified gravels of a very different character. These gravels are usually of a rusty colour, are more distinctly stratified than the quartz-drift and consist mainly of flattened schist pebbles and boulders lying loosely in a coarse sandy matrix. Quartz pebbles and boulders are also present, but are less abundant than in the quartz-drift. The passage from one formation to the other is usually gradual, but in some places is fairly abrupt.

Character of these upper gravels.

'The upper gravels resemble the stream-gravels in the present valley bottom, and have probably a similar origin, but do not carry much gold. They are found on French Hill, Gold Hill, Adams Hill and other places on Bonanza Creek and at several points along Hunker Creek. At Gold Hill they fill a depression about a quarter of a mile in width and 115 feet in depth between the ridge of quartz-drift and the southern slope of the valley. They rest near the valley on the quartz-drift, but further back overlap it and lie directly on the bed-rock. The same relationship between the two deposits obtains on Adams Hill and probably at other points, but it is only at present determinable in places where shafts have been sunk to bed-rock across the whole width of the old valley.

Distribution of old valley-gravels.

'The quartz-drift and associated upper gravels occur on Eldorado and Bonanza creeks and are found for some distance up Gauvin Gulch and Adams Creek, tributaries of the latter; on Hunker Creek and its tributary Last Chance, and on Quartz Creek and its tributary Little Blanche. They were not found on Sulphur or Dominion creeks or on any of the Indian River tributaries except Quartz Creek.

'The precise origin of the quartz-drift is still somewhat obscure. It resembles a glacial deposit in appearance, and the writer, as a

result of a hurried examination in 1898, attributed it in the Summary Report of the Survey for that year, to small local glaciers. Further and more detailed work, however, has failed to reveal any evidences of ice action either on the boulders or on the surface of the bed-rock. It is not a lake deposit, as both the upper and lower surfaces slope up valleys, heading together and running in all directions, and it does not answer to the character of an ordinary stream deposit. The angular character of the grains and the comparatively unsorted condition of the deposit, show that it has not travelled far, and it is probable that it really represents a comparatively sudden inwash from the neighbouring slopes, conditioned by an increase in precipitation acting upon a surface that had previously been deeply decomposed by a long process of subaerial decay, and operating in conjunction with a stream moving slowly down the valley. The boulders were probably rounded to some extent *in situ* and would necessarily suffer more wear on the short journey than the small particles. The sudden and somewhat tumultuous mode of deposition indicated would also account for the marked absence of differentiation of the constituents of the mass into separate beds.

Yukon District—*Cont.*

Mode of origin of quartz-drift.

Gold in Gravels—

'Gold in paying quantities occurs in the stream-gravels, the terrace-gravels and the quartz-drift, but so far has not been found in the old valley-gravels overlying the quartz-drift or in the gravels here designated as river-gravels.

Auriferous gravels.

'Gold is found in the stream-gravels everywhere, but in productive quantities only along portions of the valleys. The richest stretches usually occur about midway in the length of the streams. The distribution is however irregular and no fixed rule can be formulated in regard to it. The total length of the paying portions of the different creeks, including some intervening barren parts, aggregates about fifty miles. It is impossible to give even an approximate estimate of the value of this great stretch of pay-gravels, owing to the irregularity of the concentration and the difficulty in obtaining trustworthy returns from most of the mines. It may be stated, however, that the product of a few of the 500-foot claims on Eldorado and Bonanza creeks will exceed a million dollars each ; while a considerable number on the same two creeks (in fact, the majority of the lower Eldorado claims and a few on Hunker Creek) will yield over half a million each, and claims running from a quarter to half a million are common on all these creeks and also on Dominion and Sulphur creeks. Assuming a quarter of a million as the average, and that three-quarters of the claims in the distance given above are rich enough to work, the total value approaches $95,000,000, a figure

Gold in stream-gravels.

Possible total gold-content of these gravels.

Yukon District—*Cont.*

which is well within the mark. In this rough estimate, no account has been taken of long stretches of gravel on all the creeks, that is too low in grade to work at present, but will eventually become payable with improved conditions and cheaper methods of working, nor does it include probable further discoveries along the numerous gulches and small streams of the district, few of which have so far been carefully prospected.

Gold in terrace-gravels and quartz-drift.

'The terrace-gravels on Eldorado, Bonanza, Hunker and Dominion creeks include a few rich claims, and a large number that pay fairly well, but statistics of production are entirely wanting.

The extensive deposits of quartz-drift along Bonanza, Hunker, Eldorado and Quartz creeks, almost rival in importance the creek gravels themselves. They are everywhere more or less auriferous and are very rich over wide stretches. They suffer, however, from the scarcity of water on the hill-sides, and the ruinous methods the miners are forced to adopt, when operating on a small scale, prevent any but rich claims from being worked.

Methods of working—

Working of creek claims.

'Creek claims are worked either by sinking and drifting, or by open-cuts. The former method was the one first employed and is still very generally used, as operations can thus be carried on during the winter. The ground is frozen everywhere, and, except where the muck is free from sand or gravel and can be picked out, thawing is always necessary. This is done either by wood fires, heating the water at the bottom of the shafts with hot stones, or by steam thawers. The latter method is gradually superseding the two former and is a very simple one. A small boiler is generally used, from which the steam is passed through rubber hose, to the ends of which pointed steel tubes about four feet in length are affixed. The latter are driven into the frozen gravel, and steam is forced through them for six or eight hours. They are then withdrawn and the thawed material, removed. The points require steam equal to about one horse-power each, and thaw from one to three cubic yards of gravel at a shift. The introduction of the steam thawer is of recent date, and marks a great advance in the mining methods of the district. It thaws more rapidly than wood fires, requires at least a third less wood to do the same work, and can be used in summer as well as in winter. It has also the further great advantage over wood fires of purifying the air in place of fouling it.

Washing.

'The material drifted out from around the foot of the shaft is piled up in dumps, when the work is done in winter, and washed during the spring floods. In summer work the two operations of drifting and washing the excavated pay-gravels are carried on at the same time, if water can be obtained.

'Timbering is seldom required in summer and never in winter, as the bed of frozen muck that overlies the gravel forms an extremely tenacious roof, and chambers of astonishing size can be excavated beneath it in winter without danger. In one case on Dominion Creek, a muck roof, unsupported by pillars, covered a vault said to measure 140 feet by 230 feet which remained unbroken until midsummer. It then sank slowly down in one block, until it rested on some piles of waste material which had been heaped up to prevent accidents in case of a collapse. Examples of muck roofs spanning vaults over a hundred feet in width are common on all the principal creeks. Yukon District—*Cont.* Timbering workings.

'In working claims by the second method, that of open-cuts, the first object is to get rid of the muck covering. This is easily done in early spring by taking advantage of the spring floods and leading the water by several channels across the claim. The muck thaws readily, the streams soon cut down to the gravel, and the channels then gradually widen until they meet. In some cases the process is hastened by blowing the walls of the channel down into the stream with powder. When the muck covering is removed, the gravels soon thaw to bedrock. The upper portion, if barren, is then removed, usually by hand, and the underlying pay-gravel is sluiced in the ordinary way. Open-cast workings.

'The open-cut method of working claims leads to a more complete extraction of the gold and is the one generally preferred whenever the muck covering does not exceed 10 or 15 feet in thickness, a condition which obtains along the greater part of the principal producing creeks, with the exception of Sulphur Creek.

'The terrace-gravels are usually comparatively thin, and where uncovered by muck, are worked by open-cuts, where covered, by drifts. The pay-gravels in a few cases are sluiced in the valley-bottom, but as a rule are washed in rockers. Working of terrace-gravels.

'The quartz-drift, like the terrace-gravels, suffers from the scarcity of water, and rockers are employed for washing the pay-gravel at nearly all the working claims. A few of the principal mines have gravity trams, and when arrangements can be made with the owners of the creek claims, the creek water is used for sluicing purposes. The extent and richness of this great deposit appears to fully warrant capital in undertaking the construction of some comprehensive scheme for delivering water along the principal hills, and until this is done the greater part of the deposit must remain unworked. Of quartz-drift.

'*Machinery*—The employment of machinery in the working of Klondike claims is gradually increasing, but is still insignificant, a fact due largely to the absence of roads and the consequent impossibility of transporting heavy pieces up the creeks. Steam thawers are largely used and steam pumps are gradually replacing hand pumps, Chinese pumps and water-wheels for draining the pits. Steam hoists Machinery.

Yukon District—*Cont.*

are employed at a few of the mines, but are not in general use. The greater part of the work of the camp is still done by hand, and this, notwithstanding the fact that, taking into consideration the high price of labour, nowhere in the world could machinery be more profitably employed.

Production of District—

Approximate amount of gold produced.

'The gold production of the district can only be given approximately, but the following figures are probably nearly correct.

1897	$ 2,500,000
1898	10,000,000
1899	16,000,000
	$28,500,000

'It is unlikely that the rapid increase in production of the last two years will be continued, as serious inroads have already been made on the rich portions of Eldorado and Bonanza creeks, and to a less extent on Hunker and Dominion creeks, but the amounts remaining, with the long stretches of medium and low grade gravels still untouched on all the creeks, ensure a high production for a number of years.

Description of Creeks.

Bonanza Creek—

Description of Bonanza Creek.

'Bonanza Creek is the most important of the gold-bearing creeks of the Klondike district, and is the one on which gold in large quantities was first discovered. It heads in the Dome Ridge with branches of Quartz and Hunker creeks and empties into the Klondike River a mile and quarter above Dawson, after a course in a north-northwest direction of a little over seventeen miles. It has a drainage-area of approximately 113 square miles. It is a comparatively small stream even near its mouth, where it measures, in ordinary stages of the water, about fifteen feet in width by three or four inches in depth on the bars. It flows, however, a steady stream and furnishes at least a sluice head of water throughout the season all along the productive part of the valley. The principal tributaries of Bonanza Creek are Eldorado Creek, Adams Creek, Boulder Creek, Forty-nine Creek and Sixty-seven Creek on the left, and Carmack Forks, Homestake Creek, Gauvin Gulch, Queen Gulch and Mosquito Creek on the right.

Tributaries.

Present valley.

'*Valley.*—The valley of Bonanza Creek is characterized principally by its markedly angular trough-like shape. The present valley has been cut down in the floor of an older valley and that rapidly and almost continuously, as shown by the steep lateral walls and the absence

of continuous lines of terraces in the newer valley. The present valley usually shows a flat bottom of varying width, commonly measuring from 300 to 600 feet, bounded by steep sides 150 feet high at the Eldorado forks, and gradually increasing in elevation down the valley, or, with a steep wall of the same height on one side, and an easier slope on the other. It follows a sinuous line, bending with short curves round points that project alternately from either side. The present valley is excavated, as a rule, along one side of the older and much wider valley, and the general effect produced is asymmetrical. On one side the slope is broken, at an elevation usually of from 200 to 300 feet, by a rough plain of irregular size, but often a third of a mile wide, beyond which is an easy ascent of a thousand feet or more to the summit of the bordering ridge, while on the other side, the slope though varying in steepness is continuous throughout. Yukon District—*Cont.*

'The plain of the older valley is not noticeable in the upper part of the present valley, but becomes a marked feature at McKay Creek, three miles above the mouth of Eldorado Creek, and is then traceable along the right bank down to the Eldorado Forks. At the Forks it crosses to the left and follows the left bank to Sixty-seven Creek, then re-crosses and continues on down the right side to the point of the ridge separating Bonanza Creek from the Klondike River. Above McKay Creek, the slopes of the valley become more uniform, but continue for some distance steeper on the left limit than on the right. The bottom gradually narrows in until the valley assumes the V-shaped or gulch type and shortly after it terminates in a steep-sided, amphitheatrical depression cut out of the Dome Ridge. Old high-level valley.

'The grade of the older valley is less than that of the modern one. The rim of the older valley at McKay Gulch is 110 feet above the present valley-bottom; at the Forks it is 150 feet, and at the mouth its elevation is increased to about 300 feet. The grade of the present valley below the Forks averages about fifty feet to the mile, and that of the older valley thirty-three feet to the mile. Between Eldorado Forks and Carmack Forks, the grade of the present channel averages one hundred feet to the mile, and further up it rapidly increases. Besides the wide-spread bottom or plain of the older Bonanza valley, a number of more recent terraces occur at lower elevations. These terraces are rock-cut as a rule, are usually quite narrow, are only traceable for short distances, and occur at irregular heights. They are found at intervals all the way from Lovett Gulch up to near Victoria Gulch. Gradient of old valley. Terraces.

'*Country Rocks*—The rocks along Bonanza Creek consist almost entirely of the light-grayish and greenish sericite-schists of the Klondike series, alternating in the upper part with bands of green chloritic schists. Narrow bands of dark graphitic schists cross the valley above the mouth at Adams Creek and at one Country-rocks

Yukon District—*Cont.*

or two other points, and a wide porphyry dike forms a point about a mile below Boulder Creek. The light-coloured schist, which, as elsewhere stated, probably represents a crushed acid eruptive, occurs in heavy beds, in hard flags, and as a finely foliated and soft rock. It is nearly everywhere more or less silicified and incloses numerous quartz veins, most of which run parallel to the schistose structure, although a few cut across it.

Classification of gravels.

'*Gravels*—The gravels along Bonanza Creek fall into five groups. In order of age, commencing with the oldest, the *quartz-drift*, comes first, followed in succession by the associated *yellow-gravels*, the *river-gravels*, the *terrace-gravels*, and the *valley-gravels*. In order of economic importance the present valley-gravels come first, then the quartz-drift, followed by the terrace-gravels. The two other groups have so far not proved productive.

Valley-gravels

'The valley-gravels consist of clean, flat, fairly well worn pebbles mostly from one to six inches in length and one to two inches in thickness, derived from the light-grayish and light-greenish micaceous schists of the neighbourhood, associated with rounded and subangular pebbles of quartz, and occasional large quartz boulders usually angular in form. A few pebbles of dike-rock are also usually present. The material is wholly of local origin and is derived from the rocks outcropping along the valley. The pebbles are roughly shingled up stream, lie in a matrix of coarse sand and are occasionally interstratified, especially in their upper part, with beds of sand. They rest on a floor of broken and decomposed bed-rock, into which the gold has often penetrated to a depth of three or four feet. The gravels form a fairly uniform covering of from four to eight feet in thickness all across the flat bottom of the valley. Their width varies with the enlargements and constrictions of the valley, but usually measures from 300 to 600 feet, with occasional enlargements to 900 feet or more. The width increases gradually but irregularly down the valley.

Muck.

'The gravels are overlain by a bed of black frozen muck all along the valley from five to fifteen feet in thickness. The muck occurs in most places in a massive bed, but is also found interbanded with layers of sand. Small beds of impure muck occur in places in the lower gravels almost down to bed-rock.

Terrace-gravels.

'The terrace-gravels have a general resemblance to the stream-gravels. They are formed of the same materials but the pebbles show as a rule more wear. They are roughly stratified and include beds of fine pebbles and sand often showing cross-bedding. The terrace-gravels are of limited extent. They rest on short narrow rock-shelves distributed irregularly along the valley, on flat projecting points; or are built up at the mouths of gulches and streams. Their thickness is

from six to ten feet. They are uncovered at some points and in other places are deeply buried beneath an accumulation of muck and rocky débris from the sides of the valley. Yukon District—*Cont.*

'The river-gravels which occur in the lower part of the valley, overlying the quartz-drift, differ altogether in character from the valley-gravels. They show more wear, are better rounded, and include hard slate, quartzite and other pebbles derived from rocks not found along the creek. They are similar to the gravels in the Klondike River terraces, and as they occur only on the flat plateau separating the lower part of Bonanza Creek from the Klondike, there is little doubt that they represent the wash of the latter stream at a period previous to the general cutting down of the valleys. They measure fully 200 feet in thickness. Similar gravels also occur on the left side of Bonanza Creek, a short distance above Examiner Gulch and extend in a series of descending terraces or benches down Bonanza Creek and the Klondike River, to the Yukon valley. River-gravels.

'The quartz-drift, which with the associated yellow-gravels floors the older and more elevated Bonanza valley, has been described generally on a previous page. This unique and important accumulation of angular quartz grains, sericite and quartz boulders, is extensively, but not continuously distributed along Bonanza Creek. It is necessarily absent where the ancient and modern valleys coincide and has also been swept away in other places by erosion. It is found in descending the creek, covering small areas below McKay Creek and Homestake Creek and a much larger area below Gauvin Gulch. At the latter place it rests on a nearly level rock-floor at an elevation of about 140 feet above the present valley-bottom. It occurs uncovered along the edge of the valley, but farther back is buried beneath an accumulation of loosely stratified gravels and sand. The total width of both deposits at this point measures approximately 2000 feet, and the depth ninety feet. A shaft sunk to bed-rock, 450 feet back from the rim, showed fifty-five feet of the loose upper gravels and thirty feet of quartz-drift. The gravels of the old valley extend from Gauvin Gulch down Bonanza almost to the Eldorado Forks, but the upper gravels only are present along part of this distance, and are also traceable in a narrow band up Gauvin Gulch for a considerable distance, at an elevation of about 100 feet above the stream. Quartz-drift.

'At Eldorado Forks, the plain of the old valley crosses to the left side of Bonanza Creek. A small patch of gravel has been left on the point of the ridge separating the two creeks, and immediately opposite the Forks and extending for some distanee up Eldorado Creek and down Bonanza Creek to Big Skookum Gulch, is the important Gold Hill deposit. The gravels here cover an area about half a mile in length Plain of old valley at Eldorado Forks.

Yukon District—*Cont.*

by 1,500 feet in width and have a maximum thickness of about 116 feet. The white quartz-drift outcrops at an elevation of 150 feet and appears, so far as can be judged by the shafts, to form a great ridge following the edge of the valley, a hundred feet or more in height and 500 to 600 feet in width, with the hollow behind filled up with the yellow-gravels. The rock surface on which the gravels rest is roughened with small hollows and ridges. It extends back from the river at nearly the same general elevation for several hundred yards, then rises somewhat abruptly to the surface.

At Adams Hill.

'The quartz-drift was not observed between Big Skookum and Little Skookum gulches, but comes in again below the latter on Adams Hill and continues to Adams Creek. The gravels on Adams Hill have a width of 1,200 feet, and a depth, 550 feet back from the rim, of 130 feet. The arrangement of the quartz-drift and the upper gravels is similar to that on Gold Hill. Below the break formed by the valley of Adams Creek, the quartz-drift and stratified gravels overlaying it, occur pretty constantly, except where cut away by gulches, all the way down to Forty-nine Creek; and at one point below Mosquito Creek the upper gravels cross the valley and appear in a band 450 feet wide and ten to twenty feet in thickness on the right side. The thickness of the deposit on the left limit often exceeds 125 feet. The width is variable but usually measures from 1,200 to 1,500 feet.

Below Forty-nine Creek.

'Below Forty-nine Creek, the quartz-drift becomes less continuous for some distance. A small patch occurs below the mouth of Forty-nine Creek, a second opposite claim fifty-seven, below Discovery, and another and the last, on the left limit below Sixty-seven Creek. At the latter point it crosses the valley to the right limit above Cripple Creek, and continues down, gradually increasing in width, past Trail and Lovett gulches and across the plateau in which the ridge separating Bonanza Creek from the Klondike River terminates, to the valley of the latter. The volume of the deposit becomes greatly increased after crossing the valley. Its thickness on the hill between Trail and Cripple creeks is 225 feet, and on Lovett Gulch is not less than 110 feet. The width near the mouth of the valley is fully a mile.

Gold contents of gravels.

'*Gold contents of Gravels.*—The creek-gravels of Bonanza Creek have been found productive from near Victoria Gulch down into the eighties below Lower Discovery, a distance, measured along the valley, of over eleven miles. The values are however not uniform, and stretches occur which have proved too barren to work under present conditions. The richest and most uniform part of the creek extends from Victoria Gulch down stream for about two miles. A number of claims in this stretch will yield over half a million dollars each, or at the rate of $1,000 or more per running foot, while the product of one or two

claims is expected to double this amount. The gold contents of the gravels diminish on approaching Eldorado Forks but increase again below the Forks. A short stretch of the creek about Discovery claim, half a mile in length, including No. 2 above and the famous fraction at the mouth of Skookum Gulch, is extremely rich and in spots almost fabulously so. There is little doubt that the stream-gravels along this part of the valley have been enriched in places by gold derived from the old valley-gravels, and the same process is noticeable at other points farther down. In the lower parts of the creek, the gold in the gravels becomes finer and less plentiful, but paying claims are being worked almost down to the mouth of the valley. Gold is everywhere present, and many claims too poor to repay the great expense of mining at present, will become valuable with improved methods and reduced cost of supplies and labour. Yukon District—*Cont.*

'The Bonanza creek claims are worked both by open-cuts and by sinking and drifting. The former method is the more economical, and is the one generally employed on the more important claims, as the muck covering is comparatively thin in most places and is easily thawed and got rid of by a judicious management of the increased flow of water in the spring. The old plan of sinking and drifting is still employed on some of the claims in summer, increasingly so since the introduction of the steam thawer, and is of course the only method possible in winter. Working of creek claims.

'The terrace-gravels, except on one or two points, are usually quite narrow, and are consequently soon exhausted. They are not so productive as the creek-gravels, but a considerable number of the claims pay good "wages," or from $8 to $16 per day per man, and a few yield much higher returns. They are worked largely by rockers. Of terrace-gravels.

'The quartz-drift or old valley deposit is of scarcely less importance than the creek-gravels themselves. Claims of varying richness, often several tiers deep, have been staked on this deposit wherever it occurs, all the way from McKay Gulch down to the lower end of the valley. The most productive part extends from Eldorado Forks down-stream to near Boulder Creek, a distance of about three miles. Pay-gravels are not, however, restricted to this stretch, as good claims, by which is meant claims that yield over $10 per day per man, are being worked on the hill below Gauvin Gulch, on Lovett Gulch, near the mouth of the valley, and at a number of other points. The values could not be accurately ascertained, as statements of all kinds are current. "Colours" of gold occur all through the deposit, but the paying portion is usually confined to a band about two feet thick resting on bed-rock. The gold does not penetrate the bed-rock to the same extnt as the creek gold, and is also more patchy and irregular in its distribution. Claims on quartz-drift.

Yukon District—*Cont.*

Working of quartz-drift.

'The quartz-drift is not, as a rule, overlain by muck, and the claims in the first tier are usually worked as open-cuts until the gradually increasing thickness of the deposit compels the use of drifts. In the back tiers the claims are worked from shafts. A few of the mines tram their pay-gravels down to the bottom of the valley and use the water of the main creek or some of its tributaries for sluicing purposes; but in the majority of cases the gold is separated from the gravels by the slow and expensive method of rocking. Water is very scarce all over the area of the hill claims, but a small supply, sufficient for rocking purposes, is usually obtainable from the seepage of the mines. The richness of the hill-gravels is demonstrated by the fact that many of the claims yield high returns, notwithstanding the very heavy expense entailed in thawing out frozen gravel and washing the extracted material in ordinary rockers, in a region where labour commands a dollar an hour and supplies are purchased at rates proportionately high.

Character of gold.

'Bonanza Creek gold occurs in coarse, rough and flattish grains in the upper part of the creek, and in heavy flakes in the lower. Nuggets are not plentiful as a rule, but occur in considerable abundance near the mouth of Skookum Gulch, where they are evidently largely derived from the hill-gravels. The value of the gold is variable, but is usually about $16.50 per ounce. The gold in the quartz-drift is lighter in colour than the creek gold, is of lower grade, and is more angular and includes a large proportion of nuggets.

Bonanza Gulches—

'The most important gulches worked along Bonanza Creek are Ready Bullion, Victoria, Big Skookum and Magnet.

Ready Bullion Gulch.

'Ready Bullion enters Bonanza Creek from the left about a mile and a half above Carmack Forks and several miles above the proved productive part of the creek. It is a typical gulch, about a mile and a half in length, with a fall of nearly 300 feet in the lower mile. The valley is narrow and V-shaped above, but widens out and develops a small flat towards its mouth. The narrow gutter-like bottom of the valley is covered with from four to eight feet of coarse angular gravel and slide-rock, overlain by a few feet of muck. The stream is small, and the scarcity of water interfered seriously with mining operations during the past season. This gulch has been staked for a mile or more above its mouth. Some of the claims afford good prospects, and some gold has been extracted, but the amount of work so far done is insufficient to prove its value. The gold is coarse, rough and angular.

Victoria Gulch.

'Victoria Gulch enters Bonanza Creek from the left, one and three-quarter miles below Carmack Forks and almost at the head of the productive part of the creek. It heads with Gay Gulch, a gold-bearing

tributary of Eldorado Creek. It is about one and a half miles in length and in character conforms strictly to the gulch type. At the head is a steep regular amphitheatrical depression leading into a narrow angular valley, that gradually enlarges down the stream. It has a fall of about 900 feet. The gravels are coarse and intermixed, especially in the upper part, with unworn slide-rock. They are not deep, ranging in this respect from two to seven feet, and their width is small in the upper part of the gulch. Work has been done along the gulch for a distance of about a mile above the mouth, and on some of the claims very satisfactory results have been obtained. The gold is coarse, and in the upper part of the valley is rough and angular, with unworn edges, looking if it had just dropped out of crevices in the quartz. Yukon District—*Cont.*

'A small tributary of Victoria Gulch known as No. 7, has also been found gold-bearing for a distance of half a mile above its mouth. It joins Victoria Gulch on No. 7 claim above the mouth, and is a short, shallow gulch with a steep grade, the first 1700 feet showing a rise of 400 feet. The pay-streak is narrow, but is fairly rich in places. The gold is coarse and angular, and includes some large nuggets. A flat, oblong, unworn nugget found in No. 7 claim weighed four and one-third ounces.

'Skookum and Magnet gulches, below Eldorado Forks, differ in character from those just described. They cut through the quartz-drift down into the bed-rock beneath, and have so far not been proved productive beyond the edge of the drift. The rich claims near the mouth of both gulches have evidently derived their supply largely, if not altogether, from this older deposit, and not from original sources, as in the cases of Victoria and Ready Bullion gulches. Skookum and Magnet gulches.

Eldorado Creek—

'Eldorado Creek, the most important tributary of Bonanza Creek, is a small stream about seven miles in length and from three to six feet in width at its mouth. It carries, late in the season, barely a sluice-head of water. The valley is flat bottomed for three or four miles above its mouth, but narrow, the flats seldom much exceeding 300 feet in width. The present valley is excavated, like Bonanza valley (of which it is a continuation) in an older and wider one. It shows the same characteristics as Bonanza valley, having a trough-like depression below, 150 feet deep and from 225 to 450 feet in width, above which the slope is continuous and fairly steep to the summit of the ridge on the right limit, but on the left is interrupted by the plain of the old valley, usually about a quarter of a mile in width. At the extremity of the plain the upward slope recommences, but at a lower angle. The Character of Eldorado Creek.

Yukon District—*Cont.*

plain of the old valley extends along the left bank of Eldorado Creek for two miles above its mouth, and also occurs on the right bank for a short distance, about a mile farther up. The upper part of the valley, from Chief Gulch upward, is narrow, steep, and V-shaped. Narrow terraces occur at intervals in the lower part of the valley but do not form a conspicuous feature.

Country rocks.

'*Country-rocks.*—A few narrow trap dikes cross the lower part of Eldorado Creek, and narrow bands of dark graphitic schists were noticed in one or two places, but with these exceptions the valley is cut altogether out of the light-coloured micaceous schists of the Klondike series. Quartz veins are everywhere present, and at one point examined carried specks of free gold.

Gravels.

'*Gravels.*—The Eldorado Creek gravels are precisely similar to those on Bonanza Creek. They consist of from five to nine feet of flat, schistose and angular or rounded quartz pebbles, covering the bottom of the valley in a fairly uniform sheet, overlain by a few feet of frozen muck.

'The old valley-gravels have an elevation above the present valley-bottom, at the mouth of the creek, of 150 feet, and three miles farther up, where they disappear, of 125 feet. They consist, as on Bonanza Creek, of the quartz-drift and an upper series of stratified flat pebbles overlapping the former. Considerable areas of quartz-drift occur at the mouth of Eldorado Creek, forming part of the Gold Hill deposit previously described, and on French Hill immediately below French Gulch, while smaller patches occur about half a mile below French Gulch on the same side, and half a mile below Gay Gulch on the right limit. At the latter point, is the last occurrence of the deposit found in ascending the creek, it is quite narrow and has a thickness of only eighteen feet. It lies in a shallow pitted channel-like depression running parallel to the present valley. At French Hill, a mile and a half further down, when it next appears, it has a thickness including the upper gravel, of over a hundred feet, and a width of half a mile. The occurrences between French Hill and Gold Hill are small and unimportant.

Gold contents.

'*Gold contents of gravels.*—The productive portion of Eldorado Creek extends from the mouth of the valley up to near Gay Gulch, a distance of about three and a half miles. The gravels along this stretch of the valley are of extraordinary richness, and few breaks have been found in the continuity of the pay-streak. Some of the claims will yield more than a million dollars each, or at the rate of $2,000 per running foot, while ground running $1,000 per running foot is common. The pay-gravels extend practically, with varying values, all across the bottom of the valley, and have a thickness of from three to four feet.

The gold also penetrates the bed-rock to a depth of two feet or more. The upper part of Eldorado Creek has so far not proved productive. Yukon District—*Cont.*

'Terrace gravels of moderate richness occur along the valley at intervals from Gay Gulch down to the mouth.

'The quartz-drift is of less importance along Eldorado Creek than on Bonanza Creek, but has yielded good returns from many of the claims on French Hill.

'Eldorado gold is very coarse and is often almost unworn. Nuggets are more plentiful than on the other creeks, and are often found in an imperfectly crystalline condition. The gold is lighter in colour and of a somewhat lower grade than that of Bonanza Creek. Gold.

Hunker Creek—

'Hunker Creek is a tributary of the Klondike into which it empties eight miles above the mouth of Bonanza. It heads close to the Dome, with Dominion Creek, and flows in a north-westerly direction. It has a length of fifteen miles, and is about equal in size to Bonanza Creek. The most important tributaries are Last Chance and Gold Bottom creeks, both of which come in from the left.

'*Valley.*—The valley of Hunker Creek is remarkably similar to that of Bonanza Creek, and like it, its present form is due to a secondary valley sunk in the floor of an older one. The recent valley has a depth in bed-rock, near the mouth, of 300 feet, and including the gravels, of over 400 feet. It is a steep-sided flat-bottomed trough, two to four hundred yards wide near the mouth, gradually narrowing up the stream. Its width is more irregular than the Bonanza valley, and the basins developed at intervals in the lower part are wider. The plain of the old valley is a marked feature from the mouth up to a point half a mile above Gold Bottom Creek, a distance of eight miles. It disappears there but comes in again for a short distance a mile and a-half further up. Hunker valley.

'A few rock-cut terraces occur below the plain of the old valley, but are seldom very conspicuous. Like those on Bonanza Creek, they are narrow, irregular in height, and usually quite short.

'*Country-rocks.*—The rocks along the upper part of Hunker Creek consist of the light-coloured sericite-schists and the greenish chloritic schists of the Klondike series, cut by a few small bosses of rhyolite. From Colorado Creek to the mouth the same rocks also occur, but are associated with wide bands of the lead-coloured and dark graphitic schists of the Hunker series, some green schists and occasional bands of limestone. Country-rock

Yukon District—*Cont.*

Gravels.

'*Gravels.*—The gravels on Hunker Creek, like those on Bonanza Creek, are of four different kinds, viz., the present creek-gravels, the terrace-gravels, the old valley-gravels and a sheet of river-gravel overlying the latter near the mouth of the valley.

'The creek-gravels are all local in origin, and are similar in character to the Bonanza Creek gravels. They consist of flat schistose pebbles, sub-angular quartz pebbles and boulders, and occasional pebbles derived from the newer eruptive rocks. They have a thickness of from four to ten feet, and are overlain by a bed of muck or peaty material ranging in thickness from about twenty feet downwards At Discovery, the thickness of both muck and gravel is less than ten feet for a short distance.

'The terrace-gravels are more rounded than the creek-gravels, but are otherwise very similar. They occur in narrow disconnected strips along both sides of the valley at various elevations up to 100 feet above the present valley-bottom. They have a maximum thickness, in the sections examined, of seventeen feet, and in places are of considerable economic importance.

'The old valley-gravels have a wider distribution along Hunker Creek than on any creek in the district. They commence, in descending the valley, in a comparatively thin narrow band on the right limit opposite No. 4 below Discovery, where they occupy a basin-shaped depression on both sides of No. 6 Gulch. They are absent below this point for some distance, but reappear on the left limit half a mile above Gold Bottom Creek, and continue down on the same side, except when broken through by the valleys of the larger tributaries, to Henry Gulch, near the mouth of the valley. A few small patches also occur on the right limit between Gold Bottom and Hester creeks, and below Last Chance Creek the main deposit crosses Hunker valley and continues through in a wide band to the Klondike valley.

Quartz-drift.

'The character of the quartz-drift on Hunker Creek is similar to that on Bonanza Creek. When typically developed it is a grayish, almost white, compact deposit, consisting mainly of sericite, clear angular quartz grains, quartz pebbles and boulders and a few schist pebbles and boulders. It is also overlain in places, as on Bonanza Creek, by a yellowish loosely stratified deposit of flat pebbles, derived mostly from the Klondike schists. The thickness of the quartz-drift between Gold Bottom and Last Chance creeks ranges, as a rule, from twenty to fifty feet, and the width from 500 to 1,500 feet. Below Last Chance Creek it has a thickness of over 100 feet and a width of nearly a mile.

'The river-gravels are confined to the lower part of the valley, where they cover a flat plateau separating Hunker Creek from the Klondike above their junction, and are also found in a small terrace on the left side. They consist of well rolled and usually small pebbles of slate, quartz, quartzite, schist, granite and sandstone, occasionally interstratified with beds of sand. Yukon District—*Cont*

'*Gold contents of gravels.*—Creek claims of varying richness are being worked along Hunker valley from claim No. 42 above Discovery down nearly to No. 60 below, a distance of about ten miles, and pay-gravels are also reported from several points lower down. A stretch of the creek about three-quarters of a mile in length, about Discovery claim, has proved extremely rich, and in places is stated to yield at the rate of $1,000 per running foot. Terrace-gravels, affording moderate, and in one or two cases high returns, occur scattered along the sides of the valley from the Forks down almost to the mouth. The quartz-drift has not proved so rich as on Bonanza Creek, but numerous claims yielding fair values are being worked for some distance above and below Gold Bottom Creek and on both sides of the valley below Last Chance Creek. Gold contents.

'Hunker Creek gold, like that of most of the other creeks, occurs in coarse, bulky grains, with occasional nuggets in the upper part of the valley, and in flatter and smaller grains lower down. In the rich stretch near Discovery claim nuggets are fairly numerous. The gold from about claim No. 45 below down to No. 59 below is generally superficially darkened by iron. Gold.

'Gold Bottom and Last Chance creeks, the two principal tributaries of Hunker Creek, are both gold-bearing and have been worked to some extent for several miles above their mouths. A band of quartz-drift extends up Last Chance Creek, following the left limit, to No. 15 pup, a distance of two and a half miles, and is fairly rich in places. The gold obtained from the upper part of the band is very angular and is often crystalline. Tributaries.

Dominion Creek—

'Dominion Creek is the largest and one of the most important of the gold-bearing creeks of the district. It heads with Hunker Creek near the Dome, and flows at first in an easterly direction, but gradually bends around to the south and then to the west before uniting with Australia Creek to form Indian River. Its length, following the valley around its semicircular course, is about thirty miles. The principal tributaries are Caribou, Portland, Laura, Hunter, Gold Run and Sulphur creeks from the right, and Lombard, Remington, Champion, Nevada, Jansen, Kentucky and Rob Roy, from the left. Dominion Creek. Tributaries

Yukon District—*Cont.*

'*Valley.*—Dominion Creek valley has the general characteristics of the valleys of the district. At its head is a steep amphitheatrical depression, very regular in form, cut into the 'divide' between Dominion and Hunker creeks. Below this a deep, narrow valley is developed, with steep slopes almost meeting below. Further down, the bottom slowly widens out; small muck-covered flats, increasing gradually in width, border the winding stream, the grade diminishes and the slopes up to the high bounding ridges become easier. In the lower part of Dominion Creek the flats have an extraordinary width compared to the size of the stream. From Jansen Creek to the mouth, they nearly everywhere exceed a third of a mile and in places spread out to half a mile or more. The stream itself, at the mouth, has a width of about twenty-five feet with an average depth on the bars of about a foot.

Valley.

Terraces.

'Terraces have been traced along the left limit of Dominion Creek from a point a short distance below Lombard Creek, down to a point below Jansen Creek, a distance of twelve miles. They occur on the same side just above the mouth of Australia Creek, and probably also at points between Jansen and Australia creeks. They have not been found along the right limit. These terraces evidently mark an old stream-level. They are low, seldom exceeding forty feet in height, and in many places are scarcely twenty feet above the present valley-bottom. The terraces do not form a continuous line down the valley. The deposition seems originally to have been very irregular, and they have since been destroyed in many places, by side streams, and by erosion.

Country rocks

'*Country-rocks.*—The rocks on Dominion Creek present greater variety than on the other creeks in the district. The upper part of the valley is cut through the grayish sericitic schists of the Klondike series, alternating with bands of greenish chloritic schist. The latter is fairly massive in places and is often filled with grains of pyrite and magnetite. In the central part of the creek the Klondike schists are largely replaced by biotite-bearing schists, greenish schists and hard quartzose schists. Bands of dark graphitic schists are also present, and limestones were found in the right bank opposite claim No. 136, below Discovery, also in the dump on claim No. 123, below Discovery. These rocks resemble the schists on Indian River and are probably largely of clastic origin, and older than the Klondike schists. They are replaced about midway between Gold Run and Sulphur creeks by the area of grayish granite referred to previously as occurring on Sulphur Creek, and this rock continues on to the mouth of the valley, and down Indian River for a short distance.

Gravels.

'*Gravels*—The gravels on Dominion Creek like those of the other creeks of the district are altogether of local derivation, and consist of a mixture of flat pebbles of greenish and grayish sericitic schists in the

upper part of the creek, the same rocks accompanied by hard quartzose mica-schists below lower Discovery, and with granite in the lower part of the valley. Quartz pebbles and boulders are everywhere fairly abundant as constituents of the gravels and are often of large size. The same passage from angular pebbles in the upper part of the creek to more rounded forms farther down, noticed on the other creeks, also prevails here. Between the two Discovery claims the pebbles are smaller than usual, a fact due to the softness of the country-rock. Yukon District—*Cont.*

'The thickness of the gravel and overlying muck on Dominion Creek is less than on Sulphur Creek and about equal to that on Hunker Creek. At claim No. 20 above Upper Discovery, in the gulch part of the valley, the gravels have a thickness of three feet and are overlain by about fifteen feet of muck and sand. Between the two Discoveries, the most productive part of the creek, the gravels range in thickness from two to seven feet, and the overlying muck and associated sandy clays from about five to fifteen feet. Farther down, near the mouth of Laura Creek, the thickness of muck and gravel increases to about forty feet. The depth to bed-rock in the lower part of the creek was not ascertained as no work was in progress, but is stated to be about thirty feet. Thickness of gravels.

'The gravel in the terraces resembles that in the creeks, and consists of the same material, somewhat more rounded as a rule; but at a couple of points the terrace is built up of a mass of large angular fragments of bed-rock massed confusedly together. The thickness of the bench-gravels ranges from six to fifteen feet. They are not generally overlain by much muck.

'*Gold*—The most productive part of Dominion Creek extends from near the mouth of Lombard Creek down to a point about half a mile below Lower Discovery, a distance of about five and a half miles. The pay-streak is not uniform along this stretch, and the values, according to the present workings, are very variable. In the richer portions the gold-contents of the gravels approximate $500 per running foot, and in the poorer parts the returns have not paid working expenses. A great majority of the claims, however, situated along the portion of the creek mentioned, promise good returns if economically worked. Above Lombard Creek, a number of claims have been worked at intervals, mostly by "laymen," for a distance of over two miles, some of which have proved fairly rich. In the opposite direction, claims have been worked for several miles below Lower Discovery. At Claims No. 73D and 74 below Lower Discovery fair pay is stated to have been found. The total length of the creek along which gold in fair quantities has so far been found exceeds eleven miles. In the wide lower part of the creek considerable prospecting has been done all Distribution of gold.

Yukon District—*Cont.*

along the valley, mostly, however, as representation work, and discoveries of pay-gravel have been reported, but I was unable to verify them.

'The bench-gravels along the left side of Dominion Creek are of great importance. They commence below Upper Discovery and extend, so far as known, in an intermittent manner down to 133 below Lower Discovery, a distance of over thirteen miles. Their distribution along the valley corresponds in a general way with that of the more productive part of the creek-gravels. They extend, however, somewhat farther down the valley, as a claim was being worked during the past season opposite 133 below Lower Discovery which was said to give good returns. The terrace-gravels about Lower Discovery and up the valley to near Upper Discovery have proved extraordinarily rich in places, and some of the claims have yielded large returns for the amount of work done.

Character of gold.

'The gold on Dominion Creek, above Lombard Creek, occurs in large, rough, rounded or angular grains and in small nuggets. Farther down a mixture of heavy grains, some well worn and others quite rough, with a more flaky variety and an occasional large well worn nugget are found. A nugget weighing 8½ ounces was found on claim No. 2 below Upper Discovery. Towards the lower portion of the productive part of the creek, the gold becomes finer and more flaky and large nuggets disappear.

'The bench or terrace gold occurs in fairly large, flattened grains, more uniform in size and smoother and more worn than the creek gold. Large pieces are not plentiful, but occasional nuggets are found, the largest known to me weighing about 4½ ounces.

Mining.

'Mining on Dominion Creek is carried on by the two ordinary methods. The overburden of muck is comparatively thin along the productive portion of the creek, and the conditions are favourable for open work in summer.

'Mining has been greatly hampered by the excessive freight rates and consequent high cost of supplies and machinery, and the net product of the creek during the past season proved somewhat disappointing, notwithstanding the large gross output. A good wagon-road has, however, now been constructed by the Government, and prices will no doubt in future be materially reduced.

Gulches apparently barren.

'No pay-gravels have so far been found on the numerous gulches and streams entering the productive part of Dominion Creek, with the possible exception of some benches on Caribou Creek, reported late in the season. Towards the mouth of the creek, Gold Run and Sulphur creeks, two tributaries from the right, are both gold-bearing; but in the upper part the gold, as at present known, is confined almost entirely to

the main stream-channel. The gold is undoubtedly of local origin, and there is little doubt that discoveries on some of the feeders will eventually be made. Yukon District—*Cont.*

Sulphur Creek—

'Sulphur Creek heads in the Dome and empties into Dominion Creek two and a half miles above Australia Creek. It has a length of about seventeen miles measured along the valley. At its mouth it is a stream about twelve feet wide with an average depth on the bars of about six inches. In the productive part of the creek the water-supply is much smaller, but except near the head, one or more sluice-heads of water are usually available. The principal tributaries are Green, Friday, Meadow, and Brimstone gulches on the left, and Quinn and Black Diamond gulches on the right. Sulphur Creek

'*Valley.*--The valley of Sulphur Creek is sunk from 1,000 to 1,500 feet below the crests of the bordering ridges. The slopes are easy and very uniform, and are somewhat steeper on the right limit than on the left. In the upper part the valley is narrow and gulch-shaped with a steep grade, but it gradually widens toward the mouth, and at the same time the inclination lessens. For some distance above the mouth the grade scarcely exceeds twenty feet to the mile, as measured by the aneroid. The increase in width is fairly uniform, but slight expansions and contractions occur at intervals all the way down. At the mouth of Green Gulch, about five miles from the head of the valley, its bottom is 300 feet wide, and is cut by a narrow muck gorge thirty feet deep, in which the stream, here only about three feet in width, is confined. Seven miles farther down the valley-flat has a width of 750 feet, and near the mouth this increases to nearly a third of a mile. A general cross section of the valley, shows a flat of varying width bordering the stream, from the edges of which the surface rises gently to the bases of the main slopes of the valley; then a sharp ascent of from 700 to 1,000 feet, followed by easier slopes to the crests of the bordering ridges. A marked peculiarity of Sulphur valley is the absence all along its course of well marked terraces. Toward the mouth, breaks in the uniformity of the slope simulating terraces were noticed at several points, but when examined did not carry gravel. Sulphur Creek is singular in this respect, as gold-bearing terraces occur on all the other productive creeks of the district. Small terraces may yet be discovered as the valley has not been fully prospected, but no continuous system exists. Character of the valley.

'A second peculiarity of the valley is the slight continuous rise, referred to above, between the edge of the flat, bordering the creek, and the base of the hills, amounting in some parts to fifty feet or more.

Yukon District—*Cont.*

Bench claims have been staked along this rise, but in the places where shafts have been sunk through it, bed-rock has been found at about the same level as near the creek, and the rise has been shown to be due to a great accumulation of muck. It is possible, however, that in places some terraces may be buried beneath the muck so completely, that no signs of them appear on the surface.

Bed-rock.

'*Bed-rock.*—In the upper part of Sulphur Creek and down to about claim No. 50, below Discovery, the rocks consist principally of the grayish and light-greenish schists of the Klondike series, similar to those found on Upper Bonanza. The schists are cut by numerous quartz veins and by occasional bosses and dykes of rhyolite (?) In the lower part of the valley the schists become coarser, more granular, and appear to change gradually to a granite gneiss, and near the mouth of the creek to a granite. Exposures are scarce along the valley, and the character of the rocks can only be ascertained from specimens obtained from shafts which have been sunk into bed-rock.

Gravels.

'*Gravels.*—In the upper part of Sulphur Creek, where the narrow gulch type of valley obtains, the débris which has accumulated in the bed of the streams consists largely of angular pieces of schists and occasional fragments of little worn quartz that have slipped down the steep hill-sides. Farther down, the flattened schist pebbles become smaller and less angular, are loosely stratified and lie in a matrix of coarse yellowish and grayish sands, and are interstratified in places with beds of sand. In the ower part of the creek the dumps are whitish in colour and resemble at a distance dumps of quartz-drift. The light coloration is due, however, to the decomposed granite rocks into which the lower part of the shafts are sunk. The gravels consist mainly of the greyish and greenish schists of the Klondike series, except on the lower part of the creek, where there is a considerable addition of gneissic and granite pebbles. Quartz pebbles and boulders, angular, sub-angular, or rounded are everywhere fairly abundant, and pebbles of rhyolite, and of a dark coarse augite-porphyrite, the origin of which is unknown, are of occasional occurrence.

Thickness of gravels.

'The gravels vary in thickness from two to eight feet or more. In the productive part of the creek they average about three feet, on the claims examined. The overburden of muck on Sulphur Creek is extraordinary heavy, much more so than on the other creeks of the district. On claim No. 36 above Discovery the gravels run from three to three and a half feet in thickness, are overlain by fifty-five feet of frozen muck, so pure, that a shaft was sunk down to the gravel with pick and shovel, no thawing being required. About Discovery the muck is about forty feet in thickness, and on claim No. 33 below Discovery it is thirty feet thick and rests on three or

four feet of gravel. In the lower part of the creek the muck thins out considerably and the section of both gravel and muck is stated not to exceed twenty to twenty-five feet. No claims were being worked in this part at the time of my visit and I was unable to obtain measurements. Yukon District—*Cont.*

'*Gold contents of gravels.*—Claims were being worked on Sulphur Creek at the time of my visit at varions points from No. 69 above, to 33 below Discovery, a distance of over ten miles. Claims have also been worked at a profit in the forties below and it is stated on good authority that pay-gravels have been obtained at No. 75 below, increasing the productive part of the creek to about fifteen miles. The gold is distributed somewhat irregularly. The best part of the creek, so far developed, extends from about Green Gulch down to a mile or so below Discovery. It is estimated that in parts of this reach the yield will amount to and in places exceed $5,000 per running foot, or at the rate of a quarter of a million dollars per claim. Only a few of the claims promise this amount, but good ground has been proven to exist along the greater part of this stretch and but few blanks have so far been found. Gold contents of gravels.

'In the lower part of the creek the valley is wide, and the location of the pay-streak is a lengthy and expensive undertaking. One or more holes have been sunk on most of the claims, but the prospecting so far done has been insufficient to prove their value.

'Sulphur Creek gold is coarse, angular and nuggety in the upper or gulch part of the valley, but lower down becomes finer, shows more wear, and large nuggets are much less abundant. A sample of gold examined, as far down as No. 33 below, was flaky, but still fairly coarse and rough. It is stated that the grains increase again in weight near the mouth of the creek. Gold.

'The "black sand" associated with the gold, consists mainly of pyrite, magnetite and hæmatite, derived from the green schists of the district. The larger nuggets hold fragments of quartz, and all the evidence obtainable goes to show that the gold is of local origin, and is derived from the veins and silicified schists of the valley. Black sand.

'None of the tributaries of Sulphur Creek have so far proved productive, but it is highly improbable that the gold is confined entirely to the main valley, and it is confidently expected that future prospecting along the side gulches and streams will eventually reveal other sources of supply.

'The deep bed of muck covering the gravels along the productive part of Sulphur Creek, prevents open work, except in one or two favourable spots, and mining is carried on almost entirely by sinking and drifting. A heavy muck roof entails some extra expense in hoisting, but adds to the safety of the workings. Great depth of muck.

Yukon District—*Cont.*

Gold Run Creek—

Gold Run Creek.

'Gold Run Creek was examined only in a hurried manner for a distance of four miles above its mouth. It is one of the principal tributaries of Dominion Creek from the right and enters the latter stream about four miles above Sulphur Creek. It has a length of about eight miles and a course nearly parallel with that of Sulphur Creek. At its mouth it is a stream about six feet in width by six inches deep on the bars, but five miles above its mouth, its size has diminished to about three feet in width by three inches in depth.

Valley.

'The valley of Gold Run conforms to the general type of the country. It is flat bottomed and about a quarter of a mile wide near the mouth, with an easy gradient, but becomes narrower and rises more quickly towards its head. The bordering ridges are uneven and have a height of from 1,200 to 1,500 feet. Low terraces occur near the mouth and at some points farther up, but no continuous system exists.

Country-rocks

'The country-rocks are nearly everywhere concealed, but judging from the material on the dumps appear to be mostly green chloritic schists. At claim No. 36 a band of hard, green, rather massive rock crosses and constricts the valley.

Gravels.

'The gravels are more quartzose than is usually the case, and consist of rounded and angular quartz pebbles and boulders of all sizes up to a foot or more in diameter, and flat pebbles of the green country-rock. They range in thickness from five feet down to a few inches, and are overlain by from fifteen to twenty feet of interstratified sand and muck.

Distribution of gold.

'Gold Run Creek is singular in having its most productive part situated towards its mouth. It is possible, however, that discoveries may still be made higher up, as mining has practically only begun on the creek and it has not yet been thoroughly prospected. Claims were being worked, at the time of my visit, from a point about a mile and a half above the mouth, up the valley for about three miles. The best claims, however, so far developed, occur along a stretch of the valley a mile in length, commencing about two miles above its mouth. The gravels along this stretch have proved to be very rich in places and some of the claims have yielded good returns.

'Gold Run gold is coarse and angular and with the exception of a few smooth grains does not show much wear. Nuggets are not plentiful, and none had been found at the date of my visit over an ounce in weight.

Quartz Creek—

Yukon District—*Cont.*

'Quartz Creek, a tributary of Indian River, is a stream about nine miles in length, and has a width at the mouth of fifteen feet. It forks repeatedly along its course and with its numerous branches has carved out the widest and most conspicuous basin in the district. The principal tributaries are Calder, Little Blanche and Cañon creeks on the right, and Toronto and Mack's Fork on the left. The valleys of the main stream and the larger tributaries have the usual wide, flat bottoms in their lower parts, and are bordered in places by well marked terraces. Quartz Creek.

'Quartz Creek was the first creek on which gold was discovered in the district, but the production up to the present time has been comparatively insignificant, and at the time of my visit very little work was in progress on the creek claims. The comparative leanness of the creek-gravels, so far as known, is remarkable, as this stream with its numerous tributaries cuts nearly everywhere through the Klondike schists, the gold-bearing rocks of the district, and has carried away and presumably concentrated the metallic contents of an enormous amount of material. First discovery of gold.

'Quartz Creek is bordered on the right limit, between Calder and Cañon creeks and for some distance above the latter, by an important terrace built principally of the quartz-drift, the only instance known of the occurrence of this deposit on the Indian River slope. The terrace below Cañon Creek is 110 feet high and in places nearly a third of a mile wide, a shaft sunk on it opposite claim No. 6 below Discovery, 1,100 feet back from the rim, showed about 45 feet of quartz-drift overlain by 55 feet of the upper yellowish gravels. A second deep shaft a short distance lower down, passed through 65 feet of the yellow-drift and six feet of the quartz-drift. Quartz-drift.

'The Quartz Creek quartz-drift resembles that on Bonanza and Hunker creeks, but is rather darker in colour, shows more distinct bedding, and contains a larger proportion of schist pebbles and boulders. It has proved moderately rich in places and a number of claims are being worked along it with varying success.

'The tributaries of Quartz Creek, more especially those on the right side, afford good prospects, but no important strikes have so far been made on them.

Eureka Creek—

'Eureka Creek flows into Indian River from the south, five miles below Australia Creek. It is a small stream, about eight feet in width where it enters Indian River valley, and about ten miles in length It divides three miles above its mouth into two nearly equal Eureka Creek.

Yukon District—*Cont.*

branches, both of which head in a range of high hills that border this part of Indian River valley on the south.

Valley.

'The valley of Eureka Creek conforms to the general type of the district. In the lower part, the muck-covered flat bordering the stream is from 300 to 900 feet wide, but above the forks it soon contracts into a narrow gulch. A well-defined bench fifty feet in height occurs on the left limit opposite the forks and continues up the creek for a couple of miles. At No. 4 above Discovery, the terrace is ninety feet in height.

Rocks.

'*Rocks.*—The rocks on Eureka Creek consist of slates, slaty quartzites, dark micaceous schists and green schists, dipping at high angles and striking in an easterly direction. These are the same rocks that are found on the Yukon River below Indian River and on the lower part of Indian River and referred to as the Indian River series. They are older than the Klondike schists which they border to the north, and are probably of Cambrian age. These rocks belong to an entirely different group from those cut by the principal auriferous creeks, and the fact that they are gold-bearing greatly widens the area of possible discoveries.

Gravels.

'*Gravels.*—The Eureka stream-gravels consist mainly of imperfectly rounded pebbles of dark and greenish schist. Quartz pebbles and boulders, sometimes of large size, are also present, and granite occurs occasionally. In the upper part of the creek, the gravels as usual become coarser and more angular. The bed of stream-gravels is from four to eight feet in thickness and is overlain by from ten to twenty feet of muck. The terrace-gravels consist of the same materials as the stream-gravels but are rounder and more worn. Quartz pebbles also seemed to be rather more abundant.

Yield.

'The yield from Eureka Creek has so far been small, and at the time of my visit very little work was being done. A few prospecting shafts were being sunk, and at No. 17 above Discovery, a crew of miners were engaged in sluicing with satisfactory results. The gold obtained here was rough and fairly coarse and included a number of small nuggets. The valley-bottom at this point is narrow and steep, but the supply of water, except in the spring, is too limited for ground-sluicing, the method by which it could be worked to the greatest advantage, and is barely sufficient to supply a set of small sluice-boxes.

'Good prospects have been obtained at several points from the benches along the left limit of Eureka Creek, on which a good deal of work will be done during the present winter, and also on several claims on the right fork and on a branch of the latter.

'Prospecting on Eureka Creek is an expensive operation. Supplies are packed in by way of the Dome and Sulphur ridge, and are also

brought up the Yukon and Indian rivers in boats, but both routes are long and difficult, and until the rates are greatly reduced only the richer parts of the creek can be worked at a profit. Yukon District—*Cont.*

Other streams.

'The flat bottom-land of the Klondike valley below the mouth of Hunker Creek, and more especially from the mouth of Bonanza valley for some distance down, has afforded very good prospects, ten cents or more to the pan being reported from some of the shafts. The valley above the mouth of Hunker Creek has not, so far, proved valuable. Klondike flats

'Indian River, bordering the southern part of the Klondike region, has yielded small amounts of gold from bars. The valley-gravels are also said to yield fair prospects but are not being worked. A wide gravel terrace, that deserves attention, follows the left limit of the valley from the mouth of Australia Creek down to a point below Quartz Creek. It affords colours of gold, but has not been sufficiently prospected to prove its value. Other terraces, all carrying gold to some extent, also occur in places along the right limit, usually near the mouths of the tributaries. Indian River.

'Australia Creek, which unites with Dominion Creek to form Indian River, has been prospected to a considerable extent, but so far as the creek-gravels are concerned, with little result. A well marked and wide terrace, practically a continuation of that on Indian River, follows the left limit of the valley for a number of miles above its mouth. The terrace-gravels have a thickness of over sixty feet in places, and carry small quantities of fine gold from the surface down. A company was engaged during the past season in an attempt to locate a pay-streak, but the result of the operations is not known. Australia Creek.

'All Gold and Too Much Gold creeks, both of which rise near the Dome and near the sources of Hunker and Dominion creeks and flow outward (the former emptying into Flat Creek and the latter, into the Klondike River a short distance below the mouth of Flat Creek), were the scenes of a rush a couple of years ago, but the result has not justified expectations, and at the present time they are almost deserted. All Gold and other creeks.

'Flat Creek is bordered on the east by a plateau fully 600 feet in height and several miles in width, formed entirely of loose gravels, sand, and sandy clay. This formation is quite recent and is usually regarded by the miners as the wash of an old channel of the Stewart. It was only examined at one point and the evidence obtained there pointed to its deposition in a lake-basin. It covers a considerable area, as it is stated to run through from the Klondike to the Stewart and to extend for some distance past both streams. The deposit has been prospected to some extent and shown to contain a small amount Flat Creek.

Yukon District—*Cont.*

of fine gold, but no rich spots have so far been found. It is, however, worth investigation as a possible field for operations on a large scale.

Little general prospecting.

'Very little work was done during the past season in the Yukon district, outside the Klondike gold fields. The Stewart River was further prospected by a few parties and reports of strikes on some of the tributaries were current, but it was impossible to learn anything definite about them. A strike is also reported farther to the north on a couple of tributaries of the south fork of the Salmon, and a small quantity of coarse high-grade gold purporting to come from there, was seen by the writer when on the way out. The creeks at the head of Sixty-mile River, which were almost abandoned after the Klondike discoveries, are also again beginning to attract some attention.

'The outlying districts have been neglected by the old miners since the Klondike discoveries were made, and the work of the many inexperienced men who have overrun a large part of the country during the past two seasons has been mostly wasted. They followed each other in crowds up and down the main waterways, but did little effective work. As a matter of fact, less genuine prospecting has been done since the Klondike discoveries than in the preceding years, notwithstanding the rush. Thousands of streams in the gold belt stretching for hundreds of miles from Atlin to the Klondike and farther to the north, still remain to be explored, and the work of the prospector will not be completed for many years.'

BRITISH COLUMBIA.

British Columbia.

Field-work was in progress in three parts of this province during the past season, the Atlin district, West Kootenay and East Kootenay. Mr. J. C. Gwillim, who was appointed to the staff of the Survey in the early summer, and who was at the time in British Columbia, was entrusted with the execution of a preliminary examination and survey of the Atlin region, to which recent important discoveries of placer gold had attracted much attention. Upon this region and the work done in it Mr. Gwillim makes the following report:—

Work by Mr. Gwillim in Atlin District.

'Under your instructions, I left Vancouver on May 30, for Atlin, to begin a survey and examination of this district, which has lately become prominent as a placer mining camp.

"A. E. Porter was engaged in Vancouver for the season, and along with Mr. McConnell and his party we went north to Skagway, thence over the White Pass to Bennett, which place we reached on June 5. White Pass was nearly clear of snow at this time, but the ice on Summit Lakes was still solid enough to travel on. The upper lakes from Bennett down to Tagish had been open some days, though the spring

was late. Taku Arm and Atlin Lake had broken up about June 1 At Bennett a Peterborough canoe and other necessary articles were bought, and on June 6, with Mr. McConnell, we went on down Lake Bennett. On June 7, with one man, I began a log and compass survey along Taku Arm, travelling southward from Tagish Lake toward Atlin. British Columbia—*Cont*

'The Atlin district became known as a placer field during the summer of 1898, after Fritz Miller and his companions had staked Discovery on Pine Creek. Men went in from many different points; some from Tagish and Log Cabin, and others by way of Taku River and trail to Atlin Lake, so that the principal tributaries of Pine Creek and McKee Creek were staked before winter came. Discovery of Atlin.

'During the winter and early spring, many who had gone out in the autumn returned, and others came back by way of Log Cabin and the Fantail route from White Pass, overland from Teslin, by way of the Taku trail, and by Gladys or Sucker and Surprise lakes, with dogs or hand-sleighs. In early spring many horses and sleighs went in over the ice by way of the summer route, over Lake Bennett and Taku Arm. Previous to this discovery of gold there is evidence to show that white men had already been through the district, but apparently without finding gold.

'The method of survey employed by me was that of log and compass traverses of the lakes with micrometer or paced surveys of the country passed over by land, using mountain stations as checks, together with latitude observations. Method of survey.

'For twenty miles up Taku Arm, rough, bare, limestone ranges extend on either side, rising 2,000 to 2,500 feet above the lake. This same belt of limestone passes eastward across Little Atlin Lake, and thence towards Teslin Lake in an easterly direction. No evidence of ores was met with along this course, although, further eastward, some copper is found in the limestone. Taku Arm.

'Toochi River comes in from the west, through a low wide gap, eighteen miles from Tagish Lake. It is a good sized stream, flowing over gravel. No bed-rock was seen. Several terraces of fine material—a sandy clay with very few pebbles—cross this valley, the highest of which, two miles back from the lake, stands 230 feet above it. Such terraces, or portions of them, are common throughout the country to the south-east up to a height of 1,800 feet above the lake system, which is itself approximately 2,190 feet above the sea. Toochi River.

'Two miles south of Toochi River, the white limestone gives place to a different class of rocks and the aspect of the country changes greatly. It has a more worn-down appearance. There are often low foot-hills and broad depressions, characterized by Banksian pine, poplar Shore south of Toochi River.

British Columbia—*Cont.*

and grassy patches. The mountains are in isolated groups, rounded and grassy above the timber, which rarely runs much higher than 1,000 feet above the lake-level. The rocks underlying this portion of the country are various fine-grained igneous and sedimentary materials, usually called "slates," as distinguished from limestone or granite. Often they are greenstone eruptives, or more or less stratified dark, fine-grained rocks, sometimes of igneous origin also; but, proceeding southward, the rocks become well-defined sandstones, slates proper and conglomerates. The general course of these rocks is south-easterly, running towards Atlin Lake.

'Immediately south of the limestone the rocks just mentioned show signs of mineralization. Much of this country-rock is impregnated with iron-pyrites, iron-stained bands and patches are to be seen on the adjacent mountains, and some quartz bodies have already been staked. Little time was, however, spent here, the main object being to get into the Atlin district proper.

Golden Gate.

'Golden Gate, the narrow passage leading into Taku Inlet and Atlin, was reached on June 11. This place is about forty-two miles southwards from Tagish Lake. From Golden Gate the survey was carried eleven miles southward, up the Arm, sandstones, slates and conglomerates continuing. Thence the Arm turns abruptly westward, entering the belt of coast granites and lying between ranges from 3,000 to 3,500 feet high. This extremity of the lake ends in a deep valley some three miles long, floored with fine sand, down which comes a crooked stream, fed by one of the arms of a glacier from the Coast Ranges.

Southern part of Taku Arm.

'Near this southern end of Taku Arm the first occurrence of gold-bearing quartz was noted. Specimens of free gold, gray copper, copper-pyrites and galena were seen from this district. Concerning the extent of these deposits, however, little can as yet be said with certainty, but several quartz veins were seen. A mineralized area of schists appears to lie in the vicinity of Otter Lake, west of the Arm, and on the old Fantail route from Log Cabin. One of the claims in this locality had been more or less worked since the autumn of 1898, but without developing much of value, as far as I could learn. Further work has been done during the past summer near the Arm itself, especially on what are called the Golden Gate discoveries of free gold. These lie some eight miles south of Golden Gate, on the east shore. Very rich specimens of gold-bearing quartz have been taken from this vicinity, and it is stated a five-ton shipment was made from the Hope claim to a San Fransisco reduction company.

Taku Inlet.

'Returning to Golden Gate, we passed for thirteen miles eastward up Taku Inlet to Taku City and Portage, the surrounding moun-

tains being chiefly composed of slates and the shore low. A portage of a mile and a half leads over a low ridge into Atlin Lake. Aneroid readings make Atlin Lake thirty-eight feet above Taku Arm. The Atlin River flows out of it at this point, and is some two miles long. The water on June 18 was low, but many boats were being tracked up to Atlin Lake. A horse tramway now connects the two lakes. From Taku Portage to Atlin City is four miles across the lake. This place was reached on June 19. British Columbia.—*Cont.*

'Atlin City lies on the east shore of Atlin Lake, a mile north of the mouth of Pine Creek. A broad raised valley lies behind the town. This valley continues eastward for some twenty-five miles. It lies in the drainage basin of Surprise Lake, and of Pine Creek, which flows out of it. The rather low, rounded ranges that flank this wide valley, bound the present productive gold-bearing creeks, all of which, excepting McKee Creek, drain into this central valley. McKee Creek is a parallel stream some seven miles to the south with a basin of its own. Atlin City.

'Atlin Lake is a little over sixty miles long, nearly north-and-south. Atlin City is situated about half way down the east side, but the greater area of the lake lies to the south, amongst many islands and deep bays. The northern portion is a straight reach of water leading up to Mount Minto. The main ranges bordering on the lake are in some places isolated by broad depressions or grassy uplands. Their height reaches from 2,000 to over 4,000 feet above the lake, which is itself approximately 2,190 feet above the sea. The general timber-line lies about 1,500 feet above the lake, but sheltered positions carry trees up to 2,000 feet in some places. Above this is a short deciduous scrub, grass and broken rock. Atlin Lake

'Twenty-five miles northward from Atlin is a conspicuous isolated mountain that rises from the lake-shore to a height of some 4,500 feet above it. This is a well known landmark, often called "Jubilee Mountain" by the people of the district, but named by the boundary surveyors Mount Minto. Jubilee Mountains proper lie a little further north in the limestone belt. Mount Minto is a mass of granite. Mount Minto.

'The Birch Mountains, an equally lofty range, lie ten miles to the south on Goat or Tresa Island. These were climbed and were found to consist of a light-coloured granite porphyry, but are surrounded by low-lying sedimentary rocks. They rise to a height of 4,450 feet above the lake, or 6,640 feet above the sea, this being the greatest altitude reached during the season. Birch Mountains.

'Generally speaking, the more prominent mountain peaks and ranges are granitic while the lower levels and foot-hills are made up of greenstone, serpentine, quartzites and sandstones. Crystalline white limestone also forms conspicuous ranges both north and south of Atlin. Mountain ranges.

British Columbia—*Cont.*

'Looking westward from Birch Mountains on July 30, the rugged snow-clad Coast Ranges cut off the view at about twenty miles. To the north-east and south-east was a very extensive view over rounded grass-grown mountains towards Teslin Lake and river.

Pine Creek.

'Before continuing the survey north of Atlin City, I went up to Discovery, on Pine Creek, the centre of activity in placer mining at that time. As the closed season had been extended until August 1, less work was being done than would otherwise have occurred. Every possible bit of bench or creek ground on the gold creeks was staked, but few men were working. At this time the creek was in flood. Rockers were being used at Willow Creek and along the rocky benches twenty to eighty feet above Pine Creek, with a small supply of water available; from one to two ounces per day per man was reported as the result.

'Productive work was also being carried on at that time on Spruce, McKee, Otter, Wright, Boulder and Birch creeks, whilst many others were being prospected.

Survey north from Atlin City.

'On June 21 I engaged another canoeman (W. H. McIntosh) and continued the log and compass survey northward up Atlin Lake.

'Four miles from Atlin, on the east shore, the rusty magnesian rocks and serpentines give place to a coarse-grained granite. This granite continues for about forty miles north, toward Little Atlin Lake, where the great white limestone belt is again crossed.

'Twenty-nine miles north of Atlin, the British Columbia northern boundary (Lat. 60°) crosses the lake. From Atlin Lake it passes eastward across great swampy flats for twenty miles, thence six miles to the north of Sucker or Gladys Lake to Dawson Peaks or Three Aces, on Teslin Lake.

Little Atlin Lake.

'From the north end of Atlin Lake we ascended the Lubbock River to Little Atlin Lake. This is a swift and crooked stream about fifteen miles long. Little Atlin Lake is fourteen miles long and has a greatest width of a mile and a-half. A sounding taken half a mile from shore gave only forty feet. Boggy ground lies to the westward, then limestone ranges. Limestone also forms the White Mountains close to the east shore. Several parties of prospectors seen here had been through the country between this lake and Teslin. They had found little "slate" formation and no placer deposits, but some traces of copper and quartz veins.

'The height of this lake above Atlin is approximately eighty feet; above Lake Marsh 115 feet. From the northern end an old Indian trail runs to Tagish Houses, near Lake Marsh. A micrometer survey made this distance seven miles and a half. The same trail is said to

pass round the north end of Little Atlin Lake, thence eastward, north of White Mountains and over to Teslin Lake. British Columbia—*Cont.*

'On the way from Little Atlin to Tagish Houses the trail follows a dry pleasant valley containing hay meadows and little prairies with poplar groves. No better looking tract, from an agricultural point of view, was seen during the summer, wild hay being very scarce in Atlin district. From the meadows near the lake, a wagon-road leads to Tagish Police post. This was made by the North-west Mounted Police in order to bring in some 100 tons of hay cut there the previous summer. They also wintered many of the rougher horses in the open, and found them all able to take care of themselves. I am indebted to Inspector Primrose, of the North-west Mounted Police, for courtesy and information, at Tagish post. Trail to Tagish Houses.

'We returned to Atlin on July 4, and continued the lake-survey southward, where the lake widens greatly and has a deeply indented shore-line with many low islands, generally composed of sandstone. A day was spent on McKee Creek, at that time actively worked, and another trip of four days was made up Pike River, along the Taku trail, for twenty-five miles. Only one white man was met on this journey and he had found no good prospects. This river flows along the southern side of a wide depression and empties into Atlin Lake some three miles south of O'Donnell River, which swings in from the north and flows along the north side of the same great valley, the floor of which is chiefly composed of quartzite, grey limestone, conglomerates and soft schistose rocks. Twenty-five miles east the granites appear. Pike River.

'The survey was continued south-westward from Pike River among a labyrinth of islands and deep inlets, showing sandstones and conglomerates, with one small area of basalt.

'Sloco Inlet is the furthest east of the four waterways that lead toward the great glacier which I have called the Llewellyn Glacier. Thirty miles south of Atlin, from Sloco Inlet, a portage one mile long and 320 feet high leads over into Sloco Lake. This lake is 180 feet above Atlin Lake, but drains eastward into the Taku River and thence to Taku Inlet. Its length is seven miles.' The water is milky white with suspended mud from the glacier which lies one mile to the west. Sloco Inlet.

'The mountains here rise immediately from the lake. They have a tabular appearance, caused by different bands of volcanic rocks of a basaltic and trachytic character. These mountains rise from 3,000 to 4,000 feet above the lake and are pretty close to the ragged Coast Ranges at this point. Some quartz "float" was seen along the south side of the lake, where a stream flows in near the head of the river

British Columbia—*Cont.*

which drains this lake, known as the Sloco or Clo-cloheen River. Nothing of value was noticed here in the way of ore-bodies. The latitude of this lake is 59° 5′, it being considerably further south than its position on the maps.

'Continuing along the southern shore of Atlin Lake, several deep bays occur. The westerly one leading to a glacial river and reaching to within two miles of the glacier front.

Main glacier.

'The main glacier is a great, gently sloping ice- and snow-field, out of which rise isolated mountains and peaks with wide gaps of sky-line between them. The angle of ascent for the first 2,000 feet is about 7°, after which it becomes much more flat and snow-covered. The ice is much broken where it passes over ridges in the floor beneath, and is not easy to travel on. Indians are said to have crossed over to Taku River and Juneau on this ice, making the distance about sixty miles.

Its apparent recession.

'Many thousands of tons of granitic boulders and mud are lined along the central part of the ice-tongues that reach down into the low lands about Sloco Lake, Atlin Lake and Taku Arm. These glacier-fronts discharge a large supply of muddy water and sand in the later summer, which often colours the lakes for many miles. Apparently they have lately receded, and also sunk somewhat, since about a mile of stone-packed flats lies beyond the present margin of the ice, and lateral moraines of boulders occur on the hill-sides fifty feet above the surface of the ice-field.

'The rocks about this district are chiefly granites, greenstones and a reddish-green stratified rock, partly serpentinized. Large masses of granular quartz were seen, but it was apparently barren.

Second bay leading to glacier.

'Returning north towards Atlin along the west shore, another bay five miles deep swings in toward the glacier and Coast Ranges. Two more muddy rivers enter this bay. The most westerly one being a strong deep stream carrying more water, on July 27, than the Atlin River on June 18. Prospectors seen here spoke of good gold prospects in the vicinity, but nevertheless left the place themselves.

'Granites, greenstones and some thinly banded limestones and slates compose the northern mountains between this western bay and Taku Arm, which lies about ten miles away, to the north-west.

Channel west of Goat Island.

'From this bay the narrow western channel was followed between Goat Island and the west shore, the rocks being chiefly sandstones and conglomerates. A low wide gap leads westward, toward Taku Arm, and this appears to connect the soft slates and sandstones of that lake with similar rocks on the southern part of Atlin Lake. These rocks are probably of Cretaceous age.

'Rocks on Atlin Lake resembling those of the gold-bearing district, were noted between the north end of Goat Island and Taku Portage. There were some greenstones similar to those of McKee Creek and also some hard, jointed, black rocks like those of Birch and Boulder creeks. It is possible that there may be a western extension of these rocks between Atlin Lake and Taku Arm, but none were seen on the Arm itself. British Columbia—*Cont.*

'Atlin River, seen on July 31, before high-water mark had been reached, was carrying out a large body of water. It was estimated at 100 feet wide, six feet deep and flowing swiftly. Atlin River.

'On August 4, the canoe and outfit was sent up to Surprise Lake, eleven miles east from Atlin and about 850 feet above it. This lake is fifteen and a-half miles long. It lies within a group of rugged granite mountains rising from 3,500 to 4,000 feet above Atlin Lake. This granite is chiefly composed of coarse quartz and felspar. It breaks up easily and apparently constituted much of the glacial drift found to the northward toward Sucker or Gladys Lake. Granite mountains.

'The contact-line of this granite with the slates of the gold-bearing creeks, cuts across the western end of Surprise Lake, just east of Ruby Creek on the north and Wright Creek on the south side. East of this contact and in the granite no producing creeks are yet known. The placer mining, at present, stops abruptly within the slates and greenstones of the gold-bearing creeks. Line of contact.

'The granite here appears to be connected with that seen north of Atlin, on the shore of the lake, and was afterwards traced up Fourth July Creek to Surprise Lake. This creek is also a non-producer at present. From Surprise Lake it continues eastward towards Teslin Lake. The "slate" series has here, therefore, been interrupted and has been found to the north-east in the mountains about Gladys Lake, and in the great extent of country south-east of Surprise Lake. These are to a great extent quartzites, but rocks similar to those found at the head of Ruby Creek recur north-east of this interruption.

'A portage-path ten miles long, leads from the north end of Surprise Lake over to Gladys Lake. The height-of-land between the lakes is nearly 300 feet above Surprise Lake. Heavy banks of glacial drift of local origin cover all these upper valleys and low passes to a height of over 2,000 feet above Atlin Lake. Portage to Gladys Lake.

'Gladys Lake is about 110 feet lower than Surprise. Its length is about twenty miles, and it is drained by a river sometimes known as Thirty-mile River or North River. This river enters Teslin Lake a few miles south of Dawson Peaks or Three Aces, and was not traversed by us. Some maps have made it flow directly north Gladys Lake.

British Columbia—*Cont.*

into Teslin Lake opposite Ni-sut-lin River. My information is derived from the boundary surveyors. Boats are said to have come up, but the river is rough.

Rocks of Gladys Lake.

'Very little rock outcrops within the lake-basin. None was seen on its shores and great banks and beds of rather fine drift material cover the depressions. The cherty quartzites commonly seen later along the route to Teslin occur on the hills north of the lake. South of the lake a series of rusty-weathering and black rocks, sometimes nearly a serpentine, was seen. These rocks resemble those found on some of the gold-bearing creeks, especially Boulder and Ruby creeks, and the lower part of Pine Creek.

Streams entering Gladys Lake.

'Consolation, Davenport, Munro and Che-halis creeks flow into Gladys Lake from the south. Several of these creeks were staked in the early spring on good surface prospects. It was found that values did not increase on sinking into the drift, nor was bed-rock reached; so that they are now abandoned. The statement was made that good prospects ceased on going higher up the creeks above the level of the glacial drift; but, as far as I could observe, no stream of likely proportions is found above that level, although on some there is an almost total absence of such material. Much of this drift is composed of the broken up particles of the gray granites about Surprise Lake to the south of it.

'Sucker River comes in by a great valley from the south, near the eastern end of the lake. This valley was afterwards crossed on the way from Surprise to Teslin, and is one of the main depressions of the region.

Streams entering Surprise Lake.

'Returning to Surprise Lake, micrometer surveys were made of Boulder, Birch and Wright creeks, and paced surveys of Ruby and Otter creeks. All these except Ruby were being actively worked for gold.

Journey to Teslin Lake.

'On August 23, a pack outfit was bought, and a trip begun over to Teslin Lake by way of Wright Creek, across the head-waters of Dixie, and down Zenazie Creek to Sucker River. Crossing Sucker River immediately north of a little lake, we continued up Rapid Roy Creek, which flows round the southern base of Guardian Mountain, a conspicous landmark. Thence turning to the north and east, we came out to the upper slopes above Teslin Lake, and about fourteen miles from it. Turning southward fourteen miles along the open flanks of the range facing Teslin Lake, we struck the Taku-Teslin trail on Ptarmigan Flats. These extensive flats are without timber and lie about 2,250 feet above Teslin Lake. A steep trail leads down from them some twelve miles, into the valley and across to Teslin post, which was

reached September 1. The total distance from Atlin to Teslin post by this route is about eighty miles, over easy ground, without bad summits or bog-holes, and with plenty of grass. British Columbia—*Cont*

'The rocks along the route are black "slates" on Wright and Dixie creeks; quartzites and limestones the rest of the way, with a recurrence of black slates at one place on Ptarmigan Flats—the granite being just to the north of the valleys followed. The only evidence of work done was on Rapid Roy Creek, close to Guardian Mountain. Sluicing had been abandoned there. Little evidence of quartz was seen. Rocks noted.

'Prospectors at Teslin had spent the summer about Jennings River, between Teslin Lake and Dease Lake and McDame Creek. They said it showed poor prospects, little bed-rock, and that the country was mostly swamp, granite and volcanic rocks, basalt and scoria. This district is more heavily timbered than Atlin. Jennings River.

'On September 2, we left Teslin post to return to Atlin by way of the Taku trail. Until this date the vegetation in the valley was rank and green; but a quarter of an inch of ice formed the night before we left it. Ptarmigan Flats also had a slight covering of snow. Taku trail from Teslin to Atlin.

'The general direction of Taku trail is south-west. Recrossing Ptarmigan Flats, Hurricane River is reached at twenty-one and a-half miles. Thence rising again, the trail passes over a desolate plateau some 3000 feet above the lakes. This great mountain-mass is composed of a granite, very similar to that of the Coast Ranges. It is strewn with large boulders, and without timber or grass. Seventeen miles west of Hurricane River, a descent is made to Rapid River, thence along a little grassy valley, and along the steep western flanks of a great range of white limestone, down into the valley of the Silver Salmon at its junction with the Nakina River. This point was the furthest south and lowest level reached during the season, and is fourteen miles from Rapid River. The Pike River trail is joined some three miles further back and continues up Silver Salmon valley for seven miles, to the point reached along Pike River on July 12, twenty-two and a-half miles east of Atlin Lake. This trail has little to commend it, and compares unfavourably with the route by way of Surprise Lake. The total length from Teslin post to Atlin is about ninety-four miles.

'We left Silver Salmon, after connecting with the July survey, and crossed northward to the O'Donnell River. This river was followed twelve miles to Atlin Lake. It flows over a well exposed bed of cherty quartzite and through a limestone cañon.

'The rocks seen along the Taku trail are chiefly quartzites and granite, with great mountains of limestone near the Nakina River. At Rapid River, there are slates of possibly Cretaceous age. No signs of placer or quartz mining were seen. Rocks seen.

British Columbia—*Cont.*

'After reaching Atlin on September 11, a micrometer survey was made up McKee Creek to Otter Creek, and then down Spruce to its junction with Pine Creek.

'The remainder of the season, until September 28, was spent in looking over some of the quartz locations, and in a trip up Fourth July Creek to the Sunset basin, twenty-five miles north-east of Atlin.

Earthquake.

'An earthquake movement was felt at 12.45 sun time on Atlin Lake on September 10. This was an undulating motion, lasting about thirty seconds. It was felt as far north as White Horse, and probably further, and was most severe on the coast, where it shook up the glaciers, causing much ice to appear along the steamboat route.

'The gold-bearing creeks are taken up separately, since they will illustrate the geology and economic relations of the productive area. They are confined, so far as known, to a comparatively small area immediately to the eastward of Atlin, being apparently cut off on the east and north by granites, and on the west and south-west by rocks of sedimentary and aqueous origin, none of which have yet proved to be gold-bearing.

Gold output of Atlin.

'The output of Atlin division in placer gold is probably under one million dollars for the season. The number of men actually working on the creeks at the busiest time, in August, was between 1,500 and 2,000.

Ruby Creek.

'*Ruby Creek* lies fourteen and a-half miles east of Atlin. It drains into the north side of Surprise Lake and rises amongst deep valleys seven miles back. The rocks at the head are of a fine-grained black material, probably of igneous origin. They often weather red, and contain patches of a frangible gray limestone, as well as much partly serpentinized rock. These rocks are characteristic of much of the gold-producing district. It will take time to determine them. At present they are called "slates," but they are often very compact and massive or crystalline, forming a smooth bed-rock when not decomposed. The main bed-rock of this creek is basalt. It has been sluiced with little result. A mountain of scoria—an old volcano—lies on the west side; and the Surprise granites lie along the east side. Only one party, G. B. Parsons and others, were working here, at Discovery claim. All the creek is staked and a good deal of work has been done in the basalt cañon.

Boulder Creek.

'*Boulder Creek* is twelve and a-half miles east of Atlin and is the furthest east of the producing creeks on the north side of Pine Creek basin. The source is six miles back from the lake in slate and granite mountains. Most of the creek is staked. About two miles was producing, between the First Forks and a little below Discovery.

'Bed-rock is usually deep, and consists of a rather massive tough black and green material, lower down the stream approaching serpentine. Heavy wash and boulders fill up the narrow gulch, making much work for the individual miner on his 100 feet of ground. Some permanent frost was noted near Discovery on the west side, also a tough clay, beneath which no gold was found. British Columbia—*Cont.*

'Good pay in coarse gold has certainly come out of this creek, from one to two ounces per day per man and nuggets up to an ounce in weight are reported. The gold is usually found on bed-rock and in the loose gravel above it. All the work here is by sluicing and ditching, although water is not abundant, as such short streams are very small during August. This creek falls about 1,400 feet between the Second Forks and Surprise Lake, a distance of three and three-quarter miles.

'*Birch Creek* is nine miles east of Atlin on the same side as Boulder and is of much the same form and character. It heads some five miles back in a great series of dark, fine-grained rocks, apparently stratified. These carry quartz veins, some of which appear to be promising. All this creek is staked, although nothing is being done above the forks three miles and a-half from Pine Creek. From the forks down to Discovery, two miles, active work was going on. Bed-rock is usually deep, and is much the same as on Boulder Creek. A softer magnesian rock, somewhat like that of Pine and Willow creeks, occurs near Discovery. The gold is coarse and is found on or near bed-rock. There is a fall of about 1,000 feet between the forks and Pine Creek. Birch Creek.

'In common with all the creeks on this north side of Pine Creek basin, there is very little or no glacial drift. Since the date of our survey, it is reported that a great part of this creek has been leased for hydraulic mining.

'*Otter Creek.* This creek flows in at the head of Pine Creek from the opposite or southern side, eleven miles from Atlin. It runs in the great drift-covered plateau 1,700 feet above Surprise Lake, and eight miles south-east of it. In common with Wright, Dixie, Spruce and McKee creeks, the upper portions of this stream flow through low grassy ravines or coulées. Little bed-rock is to be seen, all this country being overlain by banks and slopes of clay and boulders, to a great extent above the timber-line. Otter Creek.

'Six miles up, this creek cuts through a ridge of black and grey stratified rocks, forming a little cañon. At this place about twenty men were making 'wages' or better, on August 25. From this point down to a second cañon, near Pine Creek valley, there was nothing being done, bed-rock being heavily covered with drift. The lower cañon is cut through this mixed coarse and fine material to the rocks beneath,

British Columbia—*Cont.*

which are quartzites, limestone and a talcose schist, containing large bodies of a barren-looking quartz. A few men were also sluicing at this place. From the upper cañon to Pine Creek there is a fall of about 900 feet. This creek is a little larger than the preceding ones.

Wright Creek.

'*Wright Creek* flows into Surprise Lake from the south side, fourteen miles east of Atlin. Like Ruby Creek, its basin skirts the western edge of the Surprise granites, and it is the furthest east of the producing creeks. Its upper portions are much like those of Otter Creek, grassy uplands of fine material, with a slate bed-rock in places. The length of Wright Creek is about six miles, its fall from the summit 1,700 feet, and its water supply in August none too large for the work being done.

'The first three miles up from Surprise Lake are rough and boggy. Little or no bed-rock is visible, and no work was being done. Above this, from twenty-eight below up towards Discovery, there is heavy covering on bed-rock; shafts from ten to fifty feet deep were being sunk, and the only Cornish pump seen in the district was at work here in a forty-foot shaft.

'From several claims below Discovery to thirty or thirty-five above, bed-rock is rather near the surface, and this stretch of about a mile is being well worked. Bed-rock is a finely cleaved, black shale or slate, heavily impregnated with iron-pyrites. The adjoining hill-sides slope directly from the mountain down to the creek-bed, which has not the flat-bottomed, filled-up appearance seen on Otter and Upper Spruce creeks. Very few boulders encumber this channel, foreign drift being scarce or absent, while the local rocks are too soft to form boulders of any size.

'The gold is found on bed-rock and in crevices, also along the adjacent banks of broken down slate, quite a large excavation in this having been made near Discovery. It is usually coarse and much mixed with black sand and pyrites, while some native copper is also found, and cinnabar was reported but not seen. The quality of the gold is somewhat finer than Pine Creek gold. Nuggets of several ounces are not uncommon. One, said to be the largest found in the Atlin district, weighed thirty-eight ounces. It was taken from No. 6, below Discovery.

Spruce Creek.

'*Spruce Creek* is the chief tributary of Pine Creek. Its length is about thirteen miles. The upper portion is simply a low grassy coulée leading over into Dixie Creek at 1,500 feet above its junction with Pine Creek, two miles east of Atlin. Fair prospects are said to be found in the banks and little hills of this upper portion, which are made up of boulders and clay of apparently local origin.

'At Eagle Point, eleven miles up, there is a little cañon cutting across gray, ribbed rocks with a slate-like cleavage. Work was going on here in September, with good accounts of values taken out. The bench-rock sixty feet above the cañon had been scraped clear of its thin covering of grass-roots and gravel, yielding, it is said, from 50 cents to $2.50 a pan, coupled with the statement that $2,800 had been taken off an area of 100 feet square. From one to three ounces per day per man was taken out according to one account. There were about twenty men working here in September. British Columbia—*Cont.*

'Below Eagle Point, the creek continues between grassy banks 50 to 100 feet high. This part of the valley-bottom is heavily covered. Much of it has been leased, but no one was working on this stretch of about three miles. Next below is another cañon in greenish-black rocks much like those of Birch and Boulder creeks. A hydraulic company is working here with a single jet. The creek now runs between steep high rock and clay banks, and is practically a gorge where little is being done. Creek below Eagle Point.

'The greatest activity is concentrated for some two or three miles above the junction with Pine Creek. Here are many water-wheels and Chinese pumps, wing-dams and ditches. Several hundred men were working here in September. Tunnels have been driven into the steep side-hills, and are said to reach a gold-bearing gravel at rim-rock, which is wheeled out to the sluices. One eighty-ounce nugget of gold and quartz mixed was taken out below Discovery. The gold is moderately coarse, and is found in bed-rock gravels and on rim-rock. Creek above its mouth.

'*Pine Creek* is the main gold-bearing creek of the Atlin district, and into it ultimately all the other gold creeks drain, excepting McKee Creek. It empties Surprise Lake, eleven miles east of Atlin, flows for five or six miles in a rather flat valley with little or no bed-rock visible; after which it falls more rapidly, cutting down to bed-rock and forming cañons in several places, until it reaches Atlin Lake, more than 800 feet below its source. Terraced flats stretch across the broad valley at intervals. These appear to be composed of pebbles and clay of glacial origin. Pine Creek.

'The chief productive area centres about Discovery or Pine City. Some two miles of the creek is here being worked with wheels, wing-dams and Chinese pumps. A good ditch has been made by the miners of Willow Creek to supply water for this old channel of Pine Creek. Bed-rock is usually a form of serpentine or a soft gray rock with many dykes. Productive area.

'The gold along the creek is found in layers of gravel on or near bed-rock. Many of the little rocky benches ten to sixty feet above

British Columbia—*Cont.*

the stream-bed furnish pay with rockers. There appears to be a concentration of gold in places wherever water has acted on the drift materials of the valley.

Willow Creek.

'*Willow Creek* is a wide filled up channel separated from Pine Creek by a little rocky ridge. Bed-rock is serpentine, overlain by gravels and sometimes by a blue clay and gravel. A section of the overburden here, shows from six inches to a foot of black surface soil, then a coarse gravel with more or less gold, below is a stratum of finer material and then more gravel. Two pay-gravels are said to be found, one below the 'muck' and one on bed-rock, but here as elsewhere values are 'spotty.' Some quartz veins, more or less mineralized, cut across the creek above Discovery. They are said to be associated with richer gravels.

'The gold is moderately coarse, often much like flax seed in size and shape, and is valued at from $16 to $17 an ounce.

McKee Creek.

'*McKee Creek*, is the only producing creek outside the drainage basin of Pine Creek. Its length is seven miles, draining the ranges immediately south of Atlin on the same side of the lake, seven miles to the south. The upper portion of this creek is nearly flat, the valley passing over into the valley of Spruce Creek. It is heavily covered with drift material, with a point of bed-rock here and there. There is a fall of about 1,500 feet between the upper flats and the lake. The bed-rock is often exposed on this lower portion, and is a rather massive greenstone which wears smooth. The creek-bottom is full of rocks and boulders. A bench or terrace runs along the north bank; otherwise this valley resembles that of Boulder and Birch creeks in most respects. Good pay, or one to three ounces per day per man is believed to have been taken out here. The part of the valley above described extends from Little Eldorado Creek to Discovery, less than one mile; below Discovery much of the ground is leased to the Atlin Syndicate Mining Company. Above Little Eldorado not much is now being done. Shafts sunk some twenty feet on the flats passed through a mixture of gravel and clay without gold.

'A fair supply of water and rapid fall are points in favour of this creek. The adjacent mountains are composed of greenstone, quartzite and limestone. Some quartz veins are staked, also some much oxidized rock on Little Eldorado. A spring of carbonated water issues into the bed of the creek above Discovery.

Other gold-bearing localities.

'This completes the description of the worked or producing creeks. The upper portion of Dixie Creek looks favourable for placer gold, and the lower portion, called O'Donnell River, has been very little

prospected, although much of it is staked. Moose Creek, southward of Pike River is also staked, but no work was in progress at the time of our visit. Gold is said to be taken out of it by the Indians. British Columbia—*Cont.*

'The gold-bearing creeks, as far as they are at present productive, lie within the area of certain recognized rocks, consisting to a great extent of serpentines and other magnesian rocks, along the valley of Pine Creek, and of line-grained green and black massive, slates, of probably igneous origin on McKee, Spruce, Boulder and Birch creeks. The only approach to slates proper is found in the black shales or slates of Wright Creek and the gray ribbed rock of upper Spruce and Otter creeks. Rocks characterizing gold-bearing area.

'Little or no gold has been taken from creeks flowing over granite, quartzite or basalt; but the quartzite bed-rock, as well exposed on O'Donnell River, has been very little prospected.

'Most of the valley systems, at their upper levels, show a large amount of drift material of glacial origin. Much of the gold may be the result of a reconcentration of this material, which is usually composed of constituents derived from the adjoining country. Drift deposits.

'On Boulder and Birch creeks there is not much evidence of glacial drift, these valleys were apparently due entirely to erosion by water. The gold appears to be of local origin. It is usually found on the bed-rock of the present or post-glacial streams, whether derived from pre-glacial concentrations or not is yet undetermined. Some of the old channels, benches, and rim-rock deposits, are older water-ways, and some of them appear to have been pre-glacial, more especially in the broad valleys of Pine and Spruce creeks. Relation of gold to these.

'At present profitable work is confined to the flats, bed-rock and benches of the streams cut out since the glacial drift was deposited, together with some adjacent older channels, such as William Creek, wherein boulder-clay and pay-gravels are both found.

'The morainic hills and valley-terraces as a rule are not known to carry gold sufficient for hydraulic working. A certain amount of superficial concentration of gold contained in them, however, appears to have occurred. The definite proof of rich gravels beneath the general burden of glacial drift, would open up large parts of the creeks now lying idle on account of depth of bed-rock. Along the upper portion of the creeks this ground would not be very valuable unless richer than usual, owing to the small amount of water available for mining. Probable importance of pre-glacial gravels.

'Generally speaking the Atlin division still offers considerable inducement in both placer and quartz. In neither case, however, as a "poor

British Columbia—*Cont.*

man's" country, or for individual operation, except in special cases and for short times. An area fifteen miles north-and-south, by twenty miles east-and-west, will include all the creeks described, and, as far as known the productive gold field of this district.

'The extension of the "slate" rocks to the north-east, south, and south-east of the present gold field may promise further placer deposits. The particular series of rocks seen about the gold-bearing creeks, however, was only noticed south of Gladys Lake, and were here heavily covered with glacial drift.

Possible quartz mining.

'The position of quartz mining in the district is at present uncertain, but the geological conditions appear quite favourable for the production of ore-bodies. Some strong veins of quartz and sulphide ores have already been staked, as well as some large outcrops of iron-stained rock, said to carry values, but not much can be said about these without a moderate amount of development and good sampling. As far as the surface indications serve to show, there are large bodies of ore or mineralized rock, but neither the value of the contents of these nor the cost of treatment has been ascertained.

Expense.

'Concerning cost of transportation, the district does not appear to be more inaccessible than West Kootenay was eight years ago. Cost of labour is at present five dollars a day without board. A strong camp capable of furnishing a large tonnage of smelting or milling ore of a value of twenty-five to fifty dollars a ton should bring about cheaper transportation and other facilities which would make such values pay to mine.

Exploration so far accomplished.

'The little work so far done amounts to no more than prospect shafts and cross-cuts, and it is unlikely that much more will be accomplished by the individual miners, owing to the cost of material and living. Companies will probably have to take up undeveloped prospects themselves, and so take most of the risk. In the meantime, the claim owner will be wise to spend some money on sampling and assaying before undertaking costly exploration of the ground. The most favourable quartz districts noticed during the summer were north of Golden Gate some twenty miles, on Taku Arm, south of the same place, and about Otter River and lake, also, along the southern fringes of Atlin Lake, and north and west of Surprise Lake.

'There is a large district of intermixed "slate" and granite south-east of the producing gold field, which is worth prospecting but is somewhat remote for quartz mining at present. So far as could be learned, the granites are practically barren, and, except for small quantities of copper, the limestone ranges have up to the present time, also proved

barren. No district or rock can be condemned as valueless. It is simply stated that appearances favoured the above mentioned localities. The Anaconda, should it turn out favourably, will be an object lesson to miners with preconceived ideas, as its associations are of a peculiar character. British Columbia—*Cont.*

'During July discoveries of native copper were made on the southern shore of Goat Island, nineteen miles south of Atlin. I was not at this place, owing to rough weather on the lake during September, and the claims of other work, and have to acknowledge the courtesy of Mr. A. H. Bramly, a London Mining Engineer, for some account of it and for some specimens of the ore. Native copper.

'Fourteen claims have been staked on the course of this discovery. The country-rock in the vicinity is sandstone, but with dykes and igneous intrusions about the southern flanks of Birch Mountains. The vein-matter consists of calcite seams with flakes and slabs of native copper, one of which was a foot in diameter and an inch thick. Besides these thin seams, there is a zone of greenish rock, impregnated with white and red calcite, and specks of native copper. The main rock itself being a green serpentine, representing an altered dyke passing through the sandstones and conglomerates. Other native copper deposits were reported from near Moore Creek, and the glacier front.

'The Currie Swan is a quartz location made by Joe. Kirkland, on May 21, 1899. It lies three and a-half miles south of Atlin, on the east side, and consists of a number of quartz seams containing galena, lead carbonate and copper stain in a quartzitic country-rock. Metalliferous veins.

'The quartz veins found about the western end of Surprise Lake and one towards Fourth of July Creek are, as usual, confined to the so-called slates. Some of these veins are well mineralized with sulphides, and others show fine gold and silver sulphide resembling some of the Kootenay ore-bodies in this report. The usual course of the veins is north or north-east, true. The dips are usually steep.

'The Pride of Pine Creek and Surprise Mountain Lode, located in August, 1898, by Fritz Miller and other pioneers of the district, on Surprise Mountain, a mile south of the lake and 850 feet above it, are on a strong quartz vein, shown by open-cut to be at least eighteen feet wide, containing galena and some copper-pyrites. This vein is in a band of altered talcose rock, that passes through the usual green and black rocks of this district. Its course is nearly north-and-south. Dip 66° west.

British Columbia—*Cont.*

'The Lake View group consists of Lake View, Grand View and Last Chance, located in September, 1898, by W. H. Brown and others, and situated half-way between Boulder and Birch creeks, 400 feet above the lake. These cover a well-defined vein three feet wide on

Lake View.

the Lake View. Its course is north-northeast; dip 70° westward, It holds galena, zinc blende, silver sulphide and free gold. The country-rock is the same as that of Boulder and Birch creeks. An opening twelve feet deep shows this vein with regular width and good walls. Other parallel veins carrying more sulphides occur in this group.

Little Edna.

'The Little Edna mining claim, situated five miles up Birch Creek on the north-east branch, was located August 15, 1899, by V. C. Spaulding and others. It covers a quartz vein six to eight feet wide containing much pyrrhotite and some copper-pyrites. The vein strikes north-northeast and dips 85° westward through a somewhat stratified series of hard black rocks of fine grain. There is a strong foot-wall with over a foot of selvage matter. Other large outcrops of quartz were seen along Birch and Boulder creeks but nothing has been done to prove them.

Sunset.

'The Sunset group lies twenty miles east of Atlin, over the head of Ruby Creek. Locations were made here on July 15, 1899, by Alex. McDonald and others. This ore-body occurs along with an area of the crumbling gray limestone characteristic of the gold-bearing rocks. Owing to the presence of snow and a cave-in of the open-cut little could be seen of the course and dip of the body of sulphides. As usual, the surface is covered with broken rock, more or less shifted from its original position, The solid sulphide ore-body consists of galena and iron-pyrites; it is over five feet across, while fifteen feet shows more or less impregnation. The course is probably north-east, since other exposures have been found in that direction. Other veins in this vicinity carry copper ores in a quartz gangue.

'The Cañon mining claim is situated on Crater Creek, a tributary of Fourth July Creek, fifteen miles from Atlin. There is said to be a strong vein, seven or eight feet wide, of quartz, containing galena. This was staked in the fall of 1898, by O'Neil.

Anaconda claims.

'Anaconda Group. The claims included in this group lie immediately south and east of Atlin, adjoining the town-site. They were staked by various parties, but have now passed under the control of Lord Hamilton's people, who are developing them this winter. This deposit is very extensive, being in places over 1,000 feet wide, and it cuts across the Pine Creek valley as a distinct band or formation. The rock is a more or less pure magnesiam carbonate or magnesite, much intersected by quartz and calcite stringers and seams of oxidized

material. The rock itself is highly impregnated with pyrites, and some of the little veins carry galena and pyrites, but values in gold are said to be found all through the mass of this altered rock, especially along the oxidized seams and cavities. Of many samples taken by drilling holes all across the outcrop, it is stated that none proved to be barren. During the winter, cross-cuts will be made, under charge of Mr. Featherston, to determine if values continue satisfactory below the surface oxidation. Should this work be satisfactory, there is a great quantity of ore already in sight along the outcrop, and a wide field for operation will be opened. British Columbia—*Cont.*

'This rock, examined microscopically and in the laboratory, proved to be an impure magnesite, containing more or less serpentine, quartz and felspar in different specimens, with iron-pyrites and occasionally galena. It is stained in parts bluish-green (probably by nickel) and also contains a green chromiferous mica. This green mica and the possible nickel stain were first supposed by the locators to indicate copper. Magnesite rock.

'The following mineral specimens were examined in the laboratory of the Survey, besides the ones already mentioned in previous pages :— Specimens examined in laboratory.

'No. 7. Native copper claims, southern shore of Goat Island, Atlin Lake. "An association of green serpentine with white and red calcite. The serpentine is evidently derived from the alteration of pyroxene pseudomorphs after this mineral being plentiful in the mass."

'Magnesite from a vein cutting weathered slates, about one mile and a half north of Pike River, on Atlin Lake. "A white, compact, massive magnesite, through which is distributed a little white quartz, approximately ten per cent."

'No. 4. From half a mile above Discovery, Pine Creek, crossing the bed of the stream as a vein. "A white crystalline ferriferous magnesite, with which is associated a little white translucent quartz and very small quantities of a green chromiferous mica." Free gold was said to have been found in this, and the green mica was mistaken for copper stain.

'A sample of water taken from the warm springs, ten miles south of Atlin, on the east shore of the lake. "This water, when filtered, was clear and bright, and of a faint brownish-yellow colour. It was devoid of odour or any marked taste. Its total dissolved saline matter was 16·53 grains per imperial gallon. A qualitative analysis showed the presence of :— Mineral waters.

Soda, very small quantity.
Lime, small quantity.
Magnesia, very small quantity.

British Columbia—*Cont.*

Sulphuric acid, very small quantity.
Carbonic acid, small quantity.
Chlorine, very small quantity.
Silica, trace.
Organic matter, trace.

'"Boiling produced a slight precipitate, consisting of carbonate of lime with some carbonate of magnesia."

'This spring is luke-warm. It has built up a channel and mounds of calcareous sinter or tufa, and appears to issue from near the contact of the O'Donnell River limestones with quartzites.

'An examination was also made of the so-called "Soda Water" found in the bed of McKee Creek, a little way above Discovery claim. It is described as a clear, bright and colourless water, devoid of odour or any marked taste. The total dissolved saline matter was 103· grains per imperial gallon. A qualitative analysis showed the presence of :—

Soda, very small quantity.
Lime, rather small quantity.
Magnesia, rather small quantity.
Sulphuric acid, trace.
Carbonic acid, somewhat large quantity.
Chlorine, trace.
Silica, trace.
Organic matter, faint trace.

'"Boiling produced a rather small precipitate, consisting of carbonates of lime and magnesia."

'This water, when fresh, is sharp and pleasant to the taste. There appears to be considerable free carbonic acid. The only deposit it leaves on the gravels is a stain of iron.

Magnesite.

'A sample of the white earthy-looking material found immediately behind Atlin town-site in large patches, when examined in the laboratory, was found to consist of "a pure white, more or less firmly compacted, yet readily friable mass of hydromagnesite." The area of these deposits is some two or three acres. They appear to be at least several feet deep. Some pits sunk for six feet show the same white material. The beds themselves are raised two or three feet above the adjacent low land.

'From these notes it appears that magnesian rocks and more or less pure forms of magnesite are common in this district. Serpentine and partially serpentinized rocks occupy much of Pine Creek basin. Magnesite occurs both as beds and in veins. True sedimentary slates or schists are not common in this district.

British Columbia—*Cont.*

Glacial deposits.

'Glacial material covers a great portion of the upper valleys and flats to a height of over 2,000 feet above Atlin Lake. Terraces of finer, apparently sorted material, were seen at many different levels from the lake-shores up to a height of 1,800 feet above Atlin Lake. No regular well-defined levels common to more than one valley system were noted, and along the mountain sides above the lake Terrans were usually absent. Across the wide up-land valleys they were common and regular. Some of these banks remote from present streams have been stated to carry colours of gold.

'The material which composes the lumpy and less sloping uplands is usually a mixture of sandy clay and partially rounded boulders, the constituents at every place examined being composed of the same rock as the adjacent hills, with an odd boulder of granite or other rock foreign to the locality. Granite boulders were also occasionally seen high up on the mountain sides apart from the general drift material.

Striation.

'Glacially rounded rock was seen in places on the mountain sides south of Atlin to a height of 600 feet above the lake. The only definite grooves or striations seen were some at the lake-shore, close to Atlin, having a course nearly north-and-south, with the lake trend.

Transport of boulders.

'The Surprise granite has been carried northwards towards Gladys Lake and Teslin, and the granite of the great plateau on the Taku trail was found in blocks on the opposite range across Hurricane River, ten miles north of its original position. Otherwise there is little evidence of far removed material. The boulders of the lake-shore and creek-beds being of local appearance. This appears to strengthen the opinion that the placer gold had its origin within the drainage basins where it is now found.

'True boulder-clay is not so commonly found as more or less assorted material, in the form of gravel and sand beds, little hills of coarse material mixed with sandy clay, and long broad terraces, with steep escarpments.

Age of valleys.

'The present valley system must have been practically cut out before the advent of this glacial covering, and old stream-beds, other than the ones now flowing, may be hidden beneath the drift. The presence of pay gravel in some places near Spruce and Pine creeks, appears to show the probability of pre-glacial channels more or less undisturbed by later events.

Climate.

'The climate of Atlin district is not severe. The vegetation and general dryness point to a small rainfall. The past summer, although unusually wet in southern British Columbia, was not nearly so much so in Atlin, although not so dry as usual.

British Columbia—*Cont.*

'The lakes *en route* probably break up before or about the 1st of June, and do not completely freeze up again until well on in the winter. No noticeable frost was seen from our arrival on June 7 until the night of September 2 at Teslin, in the lower or lake country. Snow fell on the hills 1,000 feet above the lakes on June 17, and on September 1 at Teslin. On the hills about Atlin it came to stay, in part at least, on September 27.

'Two feet of snow is said to have lain round the lake-shore last winter, and more on the mountains. It is not likely that horses would live without care and feeding, except in favourable winters, although they have done so at Tagish. Cold south-easterly winds continually pour in from the gaps of the Coast Ranges during the early summer and fall, otherwise the climate is, as far as known, very much like that of Kootenay, although considerably cooler. The winter weather is said to be bright and calm. It is not severe as compared with the country further inland as the following average temperatures will show:—

Winter temperatures.

	Fahr.
Last half November	·6
First half December	28·3
Last half December	16·6
First half January	5·9
Last half January	14·5
First half February	16·5

'The coldest periods coincided with those of West Kootenay last winter, being in November, January 1 and of February 1. The lowest recorded was 32° below zero. From Nov. 22 to December 27 the temperature never fell to zero, and on nineteen days was above freezing point.

Forest.

'The forest growth is not heavy. Banksian pine, black spruce and poplar are the common trees. Cottonwood at the mouths of streams grows to a good size. Black spruce furnishes the timber for building, it rarely has a diameter of over two feet. The areas of such timber land are small, and saw-logs are usually about one foot, by twelve or fifteen feet long. Wild hay is very scarce. Bunch grass is abundant east of Atlin Lake. No pine, tamarack, cedar or hemlock trees were seen, and birch only at Nabina River. Thirty-eight species of plants that appeared to be of interest were collected. These are referred to by Professor Macoun in his report on a subsequent page.

Fruits.

'Attempts to grow garden vegetables on the sandy soil near Atlin have not been encouraging, owing principally to raw pine ground and want of rain. There seems no other reason why these should not be

successfully grown. The native fruits are—cranberry, swamp cranberry, blueberries of several kinds, black and red currants, a few gooseberries, raspberries and muskeg berries, also service-berry *(Amalanchier)* of inferior quality. British Columbia—*Cont.*

'Transportation to the creeks is by wagon-road and pack-trail, costing from one to three cents per pound to the different creeks from Atlin City. Pack animals were cheap during last summer, but as they cannot probably be kept through the winter, they will be more expensive next season. Acknowledgments are due to many gentlemen for assistance during the season, especially to Messrs. Frazer and Wheeling of the P. P. Company, Drs. Runnals and Mitchell and Messrs. Brownlee and Lowry of Atlin. Also to Alex. McDonald and Messrs. Murray of Discovery, Pine Creek. Routes to Atlin.

'There are many routes into Atlin, none of which at present are cheaper or better than that by way of Skagway, Bennett and Taku Arm railway and steamboat service, less than twenty-four hours in transit with fair connections, and a total distance of about 140 miles from Skagway. This is both a summer and winter route.

'A probable all-rail route, if such comes to pass, will be via Bennett, Tagish and Little Atlin Lake. From Tagish over to Atlin by this way is fifty-eight miles, with a height-of-land at Little Atlin Lake approximately 115 feet above Tagish and eighty feet above Atlin Lake. The country is open and not rocky until Atlin Lake is reached. This is the route followed by the telegraph. The old Fantail route from Log Cabin is fifty-seven miles; it is a shorter winter trail, for dogs. By way of Telegraph Creek to Teslin and overland to Atlin, is slow and circuitous, but suitable for bringing in stock on foot during summer.'

Mr. R. W. Brock, during the early part of the year, was occupied in working up the field notes and specimens obtained during the previous summer in West Kootenay. In the spring he resumed field-work in this district, accompanied by Mr. W. W. Leach, who devoted special attention to the geographical and topographical part of the work. Work by Mr. R. W. Brock, West Kootenay.

Good progress was made toward the completion of the West Kootenay map-sheet during the summer, although the season proved to be a remarkably unfavourable one in regard to weather. Mr. Brock notes the chief features of the work and the results of interest arrived at, as follows:—

'On May 19 I left Ottawa with instructions to endeavour to complete the field-work necessary for the publication of the West Kootenay Area examined.

British Columbia—*Cont.*

map-sheet. The areas still remaining unsurveyed included all those west of the Columbia River, with the exception of that covered by the Rossland map (already published), a considerable area between Arrow Lake and the Slocan valley (most of the Slocan Slope, including the basin of the Little Slocan, the basin of Cariboo Creek and the country north of this lying in the map-sheet), together with a small triangular area in the lofty mountains east of Kootenay Lake, in the north-east corner of the map-sheet.

Unfavourable weather.

'For field-work, the season was exceptionally unfavourable; the spring was late and snow interfered with the work till well on in July, and from that time on the weather became broken and autumnal. In the early part of August rains set in, and these continued for a month. During this wet weather the mountains were again mantled in snow. The latter half of September was fine, but thereafter the weather again became broken and unsuitable for mountain work. On the other hand, the wetness of the season prevented forest fires and smoke, so that no annoyance was caused from that source.

Surveys made in different districts.

'Nelson was again selected as head-quarters for the season. The first work undertaken was a survey of the west shore of Lower Arrow Lake and the country lying immediately to the westward. As a transit and micrometer survey of the east side of the lake had already been made last season, a log-survey of the west shore-line of the lake was considered sufficient. After completing this work, a portage was made from Christie's ranch, at the head of the lake, into Whatshan Lakes. A couple of weeks were spent in surveying these lakes and the country in the vicinity. Although it was now July, there was still too much snow in the high mountains to allow work to be attempted in the Valhalla Mountains, so camp was moved over into the Slocan valley and the western slope of this basin was examined. About July 24, I returned to Arrow Lake and entered the Valhalla Mountains from Long Creek. After working along the Slocan divide a packing trip was made across the Trout Creek and Little Slocan divide into the mountains to the east. Subsequently, returning to the head of Long Creek, the men were sent back to Burton, and Mr. Leach and I descended the valley of the Little Slocan, following it for its entire length and emerging at Park Siding on the Slocan branch of the Columbia and Kootenay division of the Canadian Pacific Railway.

'Returning to Burton, the area between this place and Slocan Lake, and northward to the edge of the map-sheet, was next surveyed. While this work was being finished, Mr. Leach went over to Kootenay Lakes to try to fill up the blank in the north-east corner of the sheet.

'The next work undertaken was in the district between Shields Landing and Rossland and westward to the watershed between Sheep and McRae creeks on the Rossland-Gladstone trail. British Columbia—*Cont.*

'On October 8 the regular field-party was broken up, but a week or ten days was spent in finishing work at several points on Arrow and Slocan lakes that had been left over till the end of the season.

'Upon leaving Nelson on October 20, I went west along the main line of the Canadian Pacific Railway to examine the Shuswap and Nisconlith rocks in their original and typical localities in the area of the Shuswap map-sheet, and to collect representative specimens for comparison with the similar rocks of the Kootenay district. When this work was stopped by snow, I returned to Ottawa.

'In the Summary Report for last year,* a description has been given of the general character of the country between the Slocan and Columbia valleys. With the exception of the Little Slocan, all the valleys tributary to the Slocan from the west are short and steep. They head for the most part in picturesque cirques, in rugged glacier-bearing mountains. From these cirques, in which lakelets are usually found, the streams descend by leaps and bounds. The smaller streams, such as Falls Creek, opposite Silverton, are exceedingly precipitous, forming an almost unbroken succession of cascades and falls. The streams frequently debouch though cañons, although on Slocan Lake this is not so marked a feature as on Lower Arrow Lake. Topographical features.

'Parallel to Slocan Lake, a few miles to the westward, a high range of mountains extends northward from the Valhalla Mountains, forming the watershed between the Slocan and the Columbia River proper. North of the end of Slocan Lake these monntains decline in height.

'Cahill Creek, the north branch of Evans Creek, which heads with Snow and Trout creeks in the Valhalla Mountains, descends in a succession of steps, on almost each of which a lake is found. Beatrice Lake, the largest, is several miles long. It completely fills the fairly wide valley, mountain-walls rising abruptly on either hand to thousands of feet above it. The discharge from this lake is subterranean for three-quarters of a mile, after which it reaches the surface in a number of large springs. This has given rise to the mistaken idea that Cahill Creek has its origin in the pond fed by these springs, and that Beatrice Lake discharges westward, the rising ground between these two points being the watershed. In reality Beatrice Lake is some miles below the head of the stream. Cahill Lake and two others are found, lower Evans Creek

* Summary Report, Geol. Surv. Can., 1898, pp. 64-65.

British Columbia—*Cont.*

down, before this stream unites with the main fork of Evans Creek about half a mile from Slocan Lake.

Little Slocan River.

'The Little Slocan River is the most important branch of the Slocan from the west. In the centre of one of the most mountainous portions of the district, it occupies a valley remarkable for its depth, size and low gradient; for, except at its head and on the smaller branches where the descent is extremely precipitous, its declivity for a mountain valley is strikingly small. It receives numerous tributaries from all directions. About six miles up from its mouth on Slocan River, a large branch, the East Fork, bends round north-easterly behind Perry Ridge, occupying the low valley that runs through to the main Slocan valley near Slocan City. On this branch, a few miles up, are several small marshy lakes. It receives some large tributaries from the Valhalla Mountains to the north. Between it and Malvey Creek, which flows north-east into the Slocan River, is a low marshy divide.

East Fork.

'The East Fork of Little Slocan might easily be mistaken for the main stream, as its valley is wide and its bend gradually north-eastward, while that of the main branch turns sharply north-west, and, for the first few miles, is contracted into a narrow defile. But above this the main valley widens out, takes a northerly bearing and heads in the Valhalla range with that of Long Creek, which discharges into Lower Arrow Lake, five miles below the Needles, and with that of Trout Creek, which falls into Cariboo Creek near its mouth at Burton City. The two large lakes that are shown on this stream in all the previous maps of West Kootenay, as Little Slocan and Beaver lakes, do not exist. This error has probably originated through a misapprehension of the position of the East Fork with its little lakes, which is parallel to the main Slocan valley, separated from it by the narrow elevation of Perry Ridge, and through mistaking this for the main valley, which, above its contracted neck has been unfrequented even by trappers.

Cariboo Creek.

'The drainage of the whole country behind Burton City is effected by Cariboo Creek and its tributaries, Snow and Trout creeks. Cariboo Creek heads in the lofty mountains, whose eastern waters reach Slocan Lake through Nemo, Sawmill and Mill creeks. For the first seven miles its course is northerly. After receiving the North Fork, which heads with Little Trout and McDonald creeks, it takes a course a little south of west. Several streams enter it from the north, the most important being Blue Grouse, Mineral and Granite creeks. About six miles and a-half from Burton, it bends south for a couple of miles when Goat Cañon Creek, a tributary from the east, flows in. From here it turns westward and discharges into the Columbia at Burton City.

'The main valley of Snow Creek lies east, and, west, but its chief feeders come in mostly from the south, heading in the Valhallas, with Evans and Nemo creeks, which flow into Slocan Lake. It unites with Trout Creek, a short distance from the mouth of the latter. Trout Creek, as before mentioned, heads with the Little Slocan, and has a northerly course to Cariboo Creek, entering the latter near Burton City. British Columbia—*Cont.*

'The country to the west of Lower Arrow Lake, while still wholly mountainous, has not the wild, rugged aspect of the district to the east. The mountains are much lower, scarcely reaching 6,000 feet, and have rounded, subdued outlines, in striking contrast to the bold lines of the Valhalla range. The ridges are comparatively level, of rather uniform elevation and are of considerable width, so that this portion of the district presents more of the appearance of a plateau country rendered mountainous by extensive erosion, while that east of the lake conforms to the Alpine type. Character of country west of Lower Arrow Lake.

'Its system of valleys is complicated and suggestive of great changes in the drainage-system of the country. One of the most important valleys is that of the Whatshan River. It leaves the lake at the Needles and extends north, being the continuation in that direction of the north-and-south valley occupied by the main, central portion of Lower Arrow Lake.

'About three miles and a half from its mouth the Whatshan receives Barnes Creek, which drains a wide valley heading with Fire valley and the Kettle River. About half a mile above the Barnes Creek forks is the outlet of the Whatshan Lakes. These are three in number, connected by short stretches of river. The upper lake is the chief body of water. Their elevation is about 700 feet above that of Arrow Lake. From the outlet to the head of the upper lake is a little over twelve miles in a straight line. Fife Creek enters the lake from the north-west, while east of the main tributary is Stevens Creek. Its drainage.

'A low pass to the east connects the head of Whatshan Lake with Mosquito valley.

'Between the lower end of Whatshan valley and Fire valley on the west and Arrow Lake on the east, the dividing ridges were cut by several low passes.

'A trail, a little under five miles long, runs from Christie's ranch on Lower Arrow Lake to the Whatshan Lakes.

'Fire valley enters the Columbia valley from the north-west, about seven miles below the Needles. It is deep and wide and affords an

British Columbia—*Cont.*

easy pass to the head of Cherry Creek and the Kettle River. For the first few miles it parallels the lake, separated from it by a low ridge. A wagon-road from the lake, about a mile below the Needles, crosses this ridge into Fire valley, where a number of ranchers have located. From here a trail extends up the valley to the head of Kettle River and to Cherry Creek, there connecting with the wagon-road to Vernon. Fire valley is drained by Inonoaklin Creek. Eagle Creek from the west discharges into the lake through the same mouth as Inonoaklin Creek.

'Going south from Eagle Creek are Worthington, Johnston, Cinnamon, Michaud, Bowman, Dog, Pup, Brush, Moberly and McCormick creeks, but of these Johnston, Bowman and Dog creeks are the only ones of any size. They all occupy ordinary transverse valleys, and very often the lower parts of these valleys just before entering the lake are contracted into cañon-like gorges.

'From above Johnson Creek to Dog Creek, a few miles west of the lake and parallel to it, is a clearly defined ancient valley, the present stream-valleys cutting transversely through it.

Sheep Lake Plateau.

'The country south of Arrow Lake and west of the Columbia River has the appearance of a plateau of erosion, and may for convenience be referred to as the Sheep Lake plateau, from the largest of the marshy lakes found in its centre. It is drained by Blueberry Creek, which flows from Sheep Lake into the Columbia about six miles below the mouth of the Kootenay, and by Sheep Creek which flows south across the International boundary and thence eastward into the Columbia. To the west it is separated from McRae Creek by Norway and associated mountains; to the south Old Dominion and other high mountains lie between it and the Rossland country.

Railway and trails.

'A new government trail from Rossland ascends Murphy Creek, crosses into the Sheep Lake plateau and thence over Norway Mountain to Gladstone, on the new Columbia and Western Railway in McRae Creek valley. There is a trail from Shields Landing on Lower Arrow Lake, which ascends Moberly Creek and crosses over to Sheep Lake, there connecting with the Rossland-Gladstone trail. The Columbia and Western Railway, now completed as far as Grand Forks on Kettle River, follows the Columbia River and southern limb of Arrow Lake westward from Robson to Pup Creek, tunnels through from the head of this stream into Dog Creek and crosses the divide from Dog Creek into McRae Creek, which it follows to Christina Lake.

Timber.

'The country west of the Columbia has suffered greatly from forest fires, so that the trees are now mostly small second-growth. Between

the Columbia and Slocan valleys some good timber is to be found, although on account of the mountainous character of the country it is, as a rule, too scattered to be of much importance commercially. Some of the valleys have timber of economic value. That of Evans Creek was taken up last summer. But the valley of most importance in this respect is that of the Little Slocan. For almost its entire length the main valley as well as that of the East Fork is timbered with large well formed pine (*P. monticola*), cedar, hemlock and Douglas fir. Red pine (*P. Ponderosa*) is found at the park-like mouth of the valley. British Columbia—*Cont.*

'The rocks of the district examined during the season are principally eruptives, although, along the northern portion there is an important area of sedimentary rocks and crystalline schists. A short description of the rocks and their distribution between Burton and Robson, east of the Columbia to the Slocan divide, is given in last year's Summary Report.* The rocks west of Slocan Lake from Little Trout Creek south, are granites, with inclusions of mica-gneiss of greater or less extent. Between Mill and Sawmill creeks is a large inclusion of this gneiss. Southward these gneissic areas become smaller, till they finally disappear altogether. Geology

'The granite is principally the gray "Nelson" granite; toward the north end of the lake it is usually isomeric, but at the south end and on Perry Ridge it is strongly porphyritic. In the southern Valhallas and on Mulvey Creek and the east part of the Little Slocan, it is squeezed into a banded mica-augen-gneiss. In the central portion of the district it is cut, or altogether replaced, by the light-coloured acid granite. This is a granite composed mainly of isomeric quartz and light-coloured felspar; the coloured constituents, chiefly biotite, being but sparingly present or entirely wanting, though garnets are not uncommon. Pegmatitic facies are frequently met with, and dykes of this rock cut the parent and the surrounding rocks in great numbers. This rock is largely developed in the Valhallas and along the Slocan divide. Nelson granite.

'At the mouth of the Little Slocan is an area of garnetiferous gneiss. It extends north-westward to a little above the East Forks, north-eastward to the summit of Perry Ridge, and eastward to the summit of Slocan Ridge. It is in part a granite-gneiss, formed from crushed Nelson granite, but is also in part composed of older rocks, which include limestone and perhaps dolomite bands, thus resembling the rocks of the Shuswap Series. From a few miles below the mouth of the Little Slocan to the Kootenay River, the rock is mainly Nelson granite. Garnetiferous gneiss.

* Summary Report, Geol. Surv. Can. 1898, pp. 65-68.

British Columbia—*Cont.*

'The distribution of the rocks west of the Columbia and south of Dominion Mountain is shown on the Trail Creek map.* Along the Middle Fork of Murphy Creek, a band of greenstone extends northward to the Sheep Lake plateau. This greenstone is the more or less altered augite-porphyrite, that is one of the widely distributed West Kootenay rocks. It is much cut up by dykes of various porphyries, lamprophyres, and also by small andesite dykes. At the head of the Middle Fork and in its vicinity, it holds inclusions of a crystalline limestone. Often innumerable reticulating and anastemosing "dykelets" of it have penetrated the inclused limestone with apparently some absorption of material of the latter. When subjected to subsequent crushing, such a complex produces strikingly perfect pseudo-conglomerates. Of these two types may be distinguished, that in which the matrix is of greenstone and the pseudo-pebble is of limestone, and that in which the matrix is of limestone and the pseudo-pebble is of greenstone. Sometimes porphyry "pebbles" occur as well, where a dyke of the latter has also been broken by the flow of the limestone under pressure.

Greenstone area.

'The greenstone is cut off along Dominion Mountain by the Nelson granite, which constitutes the chief rock west of the Columbia to about Shields Landing on Lower Arrow Lake. On Sheep Lake plateau also, from the standpoint of areal distribution, it probably stands first, though westward, at the head of Sheep Creek and Norway Mountain, the greenstone is abundant. This granite is often cut by the same intrusions as the greenstone, particularly by wide dykes of a red, probably syenite-porphyry from the great mass of these rocks to the north. Inclusions of the greenstone are common in this area of granite. Several small areas of Shuswap-like gneisses and crystalline limestones are also included in the mass of granite in the neighbourhood of Dominion Mountain.

'From Moberly Creek north to Fire valley, the rocks belong to the "younger or red granites." The series is younger than and is intruded in the Nelson granite, and consists of a coarse red granite with a number of still younger porphyries. The granite is a coarse-grained rock in which felspar, in two varieties, reddish and grayish, (orthoclase and plagioclase), forms the chief constituent; while the others are quartz and a decomposed bisilicate apparently mostly biotite. The porphyries are generally reddish, and appear to be mostly of the family of syenite-porphyries, although they vary in texture, structure and more or less in composition. The principal constituents are orthoclase,

Younger eruptives.

*Map of part of Trail Creek Mining Division. Geologically surveyed by R. G. McConnell.

plagioclase, biotite, and a diopside-like pyroxene with a little quartz. Felspar is generally the most prominent porphyritic constituent, although in some cases the coloured constituents are also conspicuous. Along their contacts they have usually a well-marked fluxion structure, and trachytic and other effusive facies are common. The eruption of these porphyries has taken place at many successive periods, between which there has been time for the already extruded rock to cool. This is proved by the way in which these dykes cut one another and the distinct salcand along the border of the younger dyke. The greater part of this area consists of a complex of these dykes. They also frequently cut the surrounding older rocks. The white dykes that are found associated with the ore bodies of the district would appear to be an acid facies assumed by these dykes at some distance from the parent mass. British Columbia—*Cont.*

'Near the borders of the main area are numerous inclusions of the older rocks. Often when these are basic, the acid eruptive in innumerable vein-like stringers has eaten into them, leaving reniform nuclei of the original rock. The result is a conglomerate-like mass. Frequently the peripheries of the nuclei are partially altered. These rocks are well seen in the cutting of the Columbia and Western Railway along Arrow Lake. A little north of Fire valley, the red granite is replaced by the white acid granite, that is in all probability merely an acid varient of the former; although the precise nature of the relationship between these two rocks was not proved. The acid granite extends to about Whatshan River, where the older Nelson granite is the country rock. This extends almost to the head of Whatshan Lake and to the bend of the Columbia, just below Mosquito Creek. At Whatshan River it is cut by a gray fine-grained somewhat prophyritic rock consisting mainly of a gray felspar and a bisilicate which has decomposed to biotite and iron-oxide. While younger than the Nelson granite, this rock is older than the acid and red granites. North of Whatshan Lake through to Mosquito Creek, and along the north slope of the mountain south of the Columbia, between Mosquito and McDonald creeks, the rocks are Shuswap-like mica-schists, gneisses and crystalline limestones. Along Cariboo Creek from Mineral Creek to the North Fork and also on the Ruby Mountains, north-east of the divide between McDonald and Little Trout creeks, is a dark grayish-green porphyritic rock. Occasionally this rock is brecciated and fragments apparently of the augite-porphyritic are included in it. Macroscopically it resembles some of the rocks found in the Columbia volcanic group in the southern portion of the West Kootenay sheet. It cuts the sedimentary rocks, but its relationship to the other eruptive rocks Inclusions of the older rock. Crystalline schists.

British Columbia—*Cont.*

in this neighbourhood was not clearly ascertained. Besides the porphyry dykes which traverse all the country-rock of the district, there is a series of green and black lamprophyres, which cut all the other rocks. They are to be met with in all parts of the district, but they appear to be particularly abundant in the regions most cut up by the porphyries.

Sedimentary rocks.

'From Little Trout Creek, near the head of Slocan Lake, to the mouth of McDonald Creek on the Columbia, is a band of dark carbonaceous limestone, calcareous quartzite and slate-like rocks, similar to the Slocan series of the Sandon region, and of which they form the westward extension. They continue northward along the Nakusp and Slocan valley to Summit Lake, where they are cut off by Nelson granite; from McDonald Creek they extend northward along Upper Arrow Lake. Where cut by eruptives, these rocks are often metamorphosed, the carbon being expelled and mica developed, so that instead of presenting a slate-like appearance, they become yellow or gray calcareous mica-schists. Along the south fork of Cariboo Creek, running south from the main band of Slocan rocks and surrounded by granite, is an area of gray mica-schists, that may be the metamorphosed form of the Slocan rocks. No definite information has so far been obtained regarding the date of this series, but they are supposed to be of about Carboniferous age. Unfortunately, the only fossil form so far obtained, does not throw much light upon the question. It is a brachiopod, probably a *Chonetes*, which was found this summer in a carbonaceous limestone boulder, in all probability, from the Slocan series. It was picked up in the drift behind Nelson.

Glaciation.

'The region examined this summer, as also that examined last season,* furnished additional evidences of the extent of the great Cordilleran glacier. In all parts of the district (except on the actual summits of the Valhalla range where disintegration and weathering have obliterated any traces of glaciation if such existed) are to be found erratics, perched boulders, well marked fluting and striation and every evidence of heavy glaciation, and the general trend of the ice-movement remains constant throughout.

'A number of the small local glaciers of the Valhalla Mountains were examined; while some show evidences of fluctuations, in general all are retreating.

'Numerous terraces of silts and gravels, similar to those observed last year along the east shore of Lower Arrow Lake*, were found along the west shore of the lake and along the Whatshan and Slocan valleys.

* Summary Report, Geol. Surv. Can.1 898, p. 68.

'Short descriptions of the nature of the West Kootenay ore-bodies have already been published.* The observations of the past season tend to confirm the opinions already expressed. Additional evidence of the probable relationship between the white porphyry dykes, and the deposits of economic minerals, pointed out in last year's Summary Report, seems to be furnished by the fact that in the districts cut through by these rocks mineralization has taken place; whereas where the dykes are wholly absent, this has not occurred. In the greater part of the Valhalla and Little Slocan country, few of the geological conditions and little evidence of mineralization was observed, and almost no claims have been taken up in this portion of the district. British Columbia—*Cont.* Economic geology.

'In the northern portion of the district, the dark slate-like rocks of the Slocan series, the same rocks that are found in the highly mineralized Sandon region, occur over a wide area, but it is only at certain points (where these rocks are dyked, and are, in this respect also similar to the Sandon rocks) that mineral impregnation to any important extent has taken place. On Cariboo Creek, such conditions are met with. Consequently there are a number of claims, upon which more or less work is being done. On the Chieftain claims, five men were employed prospecting and developing. The ore consists of auriferous and argentiferous pyrite, chalcopyrite, galena and zinc-blende in a quartz gangue. It occurs in small, rudely parallel veins in the dark Slocan rocks. On the Silver Queen, a force of men has resumed work, interrupted in the winter of 1899 by snow slides. Some work was also being done on the Millie Mac. In addition, development-work was being done on a number of private claims. At some points, as on Mountain Meadow claim at the head of Granite Creek, the gray granite is also well mineralized, with veins of argentiferous galena. Burton City camp.

'At the Big Ledge, west of Upper Arrow Lake and opposite Halcyon Springs, to which attention was called in my report of last year, considerable work has been done. The information gained regarding the tenor of this mass of sulphides is said to be encouraging. A wagon-road to the deposit was being constructed.

'The new government trail from Rossland to Gladstone has given access to the Sheep Lake and Norway Mountain district, and a large number of prospectors were at work opening up various claim situated in this area. Where prospectors are at work.

'At the close of the season, prospectors who had gone from Fire valley into the country at the head of Kettle River, returned with

* Annual Report, Geol. Surv. Can. (N.S.) vol. IX. 1896, p. 27 A. Summary Report, Geol. Surv. Can. 1898, pp. 68-69.

British Columbia—*Cont.*

reports of valuable discoveries in that district. On account of the lateness of the season, I was unable to go into the district to verify these reports, but it seems not improbable that the country west of the large area of eruptives, that occur in such mass about Lower Arrow Lake, conditions may exist similar to those found to the north, east and south of this area, where the country-rock is so richly mineralized and so many producing mines have been located.

'In some specimens kindly furnished me from this new locality, is one of a dyke-rock similar to the light-coloured porphyries spoken of as being characteristic of the mineralized portions of West Kootenay. One specimen, said to be from David Whitley's claim at the head of Kettle River, consisted of jamesonite and native gold. Tellurides, platinum and iridium were supposed to occur, but in the specimens obtained, which Dr. Hoffmann examined, none of these minerals were found, the small metallic grains proving to be pyrrhotite and specular iron.

General progress of West Kootenay.

'The mineral output of West Kootenay during the past season has been seriously affected by labour difficulties, arising from a reduction of the wage-scale upon the passing of a provincial eight-hour law. Altogether on this account, a number of the mines have been temporarily closed down. Others are doing a little work on contract labour. Many of the mines continuing active operations have been handicapped by the employment of unskilled labour. While the greater part of this district has been affected, the output of the productive Slocan has suffered most severely from these causes. A great number of the miners who abandoned work owing to the labour troubles, took to prospecting or to work on private claims, but for this the weather was very unfavourable. Thus in spite of the improvement in many of the prospects through increased development, and of the additions to the list of shipping properties, the past season has been somewhat disappointing to those who had held the well founded expectations of immediate great progress in West Kootenay.

Rossland.

'The progress of the Rossland district, however, has been very marked. Although the Le Roy, the greatest producer, cut down its output for some time to enable development work to be pushed ahead, and to execute numerous improvements in the mine, and the War Eagle, the second great producer has been somewhat handicapped in the matter of hoisting, yet in spite of these facts the output for the Rossland district will this year greatly exceed, both in tonnage and value, that of any previous year. There is also every prospect of important additions to the list of shipping mines.'

Mr. J. McEvoy was engaged during the early part of the year 1899 in completing the work of the previous summer's exploration of the Yellowhead Pass route, from Edmonton to Tête Jaune Cache, and in preparing a report upon the same. British Columbia—*Cont.* Work by Mr. McEvoy.

Mr. McEvoy left Ottawa on the first of June for the purpose of making a preliminary geological and topographical examination of the south-western part of the East Kootenay District, B.C. On the work accomplished he reports as follows:—

'East Kootenay first attracted attention on account of its placer diggings on Wild Horse Creek, Bull River, Perry Creek and Moyie River. It was the objective point of the Dewdney Trail that was built from Hope on the Fraser River, in 1865. More recently, however, this district has come to notice on account of the discovery and development of lode mines. The construction of the Crow's Nest line has given a great impetus to this industry. Mines that were formerly only shipping a small quantity of ore are now making arrangements for operating on a larger scale and fresh capital is coming in and developing new properties. East Kootenay district.

'The part of the district examined is, roughly speaking, seventy miles square. The base of this square is on the International boundary line, extending from the Kootenay River at Tobacco Plains westward to a point opposite the head of Kootenay Lake. A part of the Goat River mining division of West Kootenay is included in this area. It is needless to say that a thorough examination of all this country could not be made in one season's work, but it is hoped that the results, when compiled, will give some information about the geology of a country hitherto practically unknown in that respect, as well as something definite as to its natural resources. egion examined

'The Kootenay River in this district occupies the southern end (in Canadian territory) of the great "inter-montane" valley, whose course has now been traced for over 800 miles in a north-westerly direction from the 49th parallel. The valley attains perhaps its greatest width in this part of its length, being over twenty miles wide a little north of Cranbrook. The greater part of this wide portion of the valley has an elevation of about 300 feet above the river-level, while the low bottom-land of the stream itself, or, as it may be termed, the secondary valley, rarely exceeds a mile in width. Kootenay valley.

'Three or four miles to the east of the Kootenay River, the Rocky Mountains rise abruptly, while on the west after a gentle slope for fifteen miles, the mountains of the Selkirk or Purcell range rise more gradually and are deeply penetrated by tributaries of the Kootenay.

British Columbia—*Cont.*

With the exception of two prairies, the St. Mary prairie on St. Mary River and Josephs Prairie on Josephs Creek, and a few smaller areas, the whole of the Kootenay valley is covered with an open growth of large trees. The mountain-slopes are more thickly clothed, except where too precipitous.

Cranbrook to Wardner.

'Starting from Cranbrook, which was made head-quarters during the summer, the line of the railway was followed eastward as far as Wardner, passing through Isidore Cañon, a narrow gap through the low ridge of hills lying between Josephs Prairie and the Kootenay River. The rocks are well exposed in the cañon and consist of light-gray slightly schistose felsite, dark-coloured impure quartzite, bands of black slate and some dark-blue flaggy limestone, weathering brownish-yellow, but not containing much magnesia.

'The age of these rocks must be considered as somewhat doubtful, but from their lithological character and situation it appears very probable that they are referable to the Carboniferous. They extend westward and northward and occupy a considerable area of the wide portion of the valley before mentioned. A few miles before Wardner Station was reached, the hills to the south-west of the railway showed exposures of limestone

Limestones south of Wardner.

'South of Wardner along the route down the west side of the Kootenay River, this limestone continues as far as Plumbob Creek, a distance of about ten miles. It is generally fine-grained, gray and bluish in colour and sometimes cherty. Some beds occur of a brownish-gray rather crystalline magnesian variety. While no fossils were found to determine the age of these beds, and from their appearance they might belong either to the Carboniferous or Devonian, the fact that Carboniferous rocks are known to occur in many places in the southern interior of British Columbia, and that there is so far no positive information as to the existence of the latter, is perhaps sufficient reason to provisionally class them as Carboniferous. These limestones do not extend very far back from the Kootenay River, for the width of the area does not appear to be more than six miles at any place.

Plumbob Creek to Boundary line

'South of Plumbob Creek, the trail traverses a flat strip of country that extends for several miles back from the river. Near the river are extensive terraces rising from two hundred to three hundred feet above the Kootenay, marked in places by long drift ridges parallel to the valley and some higher ground formed by irregular gravel hills with numerous pot-holes.

'Along the Kootenay River, about twelve miles below the junction of Elk River, a few exposures show light-yellow fine-grained crystalline dolomite interbedded with siliceous shales. Farther down, at a point, two and a-half miles north of the mouth of Gold Creek, the north end of an area of volcanic rocks is reached. It contains a great variety of greenish amygdaloidal rocks, very fresh in appearance, that are evidently not older than Tertiary. This area extends to the Boundary line, increasing to a width of at least four miles at the southern end. British Columbia—*Cont.* Tertiary rocks on Gold Creek.

'Following up Gold Creek from its mouth, the route crosses first the wide terrace-flat before mentioned and then a series of parallel drift ridges, increasing in elevation as the distance from the river is increased. Only a few exposures are to be found, consisting of thin-bedded quartzites and shaly quartzites, both showing ripple-markings. A mile and a-half above the junction of the South Fork, a trail that leaves the Kootenay River near Plumbob Creek, crosses Gold Creek and leads south-westward to the head of the East Fork of Yahk River. This was one of the exploratory routes for the Canadian Pacific Railway. It joins the present constructed line at Yahk station on the Moyie River. This route was followed to the point where it crosses the Yahk River. Gold Creek to Yahk River.

'Near the junction of the South Fork and for some distance below it, Gold Creek occupies a deep narrow valley, with wooded hills rising steeply on each side to a height of 1,500 feet. The valley of the South Fork is of the same character for two or three miles, above that it becomes wider and the stream winds about it in a flat valley with natural meadows and willow swamps. A stony terrace-flat forms the divide between a tributary of the South Fork of Gold Creek and the East Fork of Yahk River. The latter stream has a caon-like valley for nearly its whole length, with steep, almost precipitous sides.

'On the west side of Gold Creek near the crossing, the trail passes over a low hill composed of purplish dolomite thinly bedded and twisted. The remainder of the route shows thin-bedded quartzites and greenish, slightly calcareous flaggy argillaceous shales with some black slate. The quartzites and shales frequently show ripple-marks and rusty spots around cavities that may have been filled with crystals of some mineral, but which are now too indistinct in form to be determined. Mud cracks are preserved in some of the shaly beds. These beds have undergone very little alteration. No signs of schistosity were seen and their attitude is nearly horizontal with occasional low north-easterly dips.

'The East Fork of Yahk River joins the main stream about half a mile north of the Boundary line. The trail then ascends the main stream Ascent of Yahk River.

British Columbia—*Cont.*

for a distance of five miles, and, crossing there, it runs westward to the Moyie River. Instead of following the trail it was decided to ascend the Yahk River to its head. The general course of the stream is north-and-south, through a heavily wooded country partly overrun by fire. In such a country and without any trail, progress was necessarily slow. Near the head of the river the valley was abandoned and a route was taken along the top of the mountain ridge on the east side. The highest point of the ridge, Yahk Mountain, is about 7,200 feet above the sea. It is the culminating point of all the country south of Cranbrook and between the Moyie and Kootenay rivers. In comparison with the rugged snowy peaks in view both to the east and west beyond its limits, this particular part of the country may be spoken of as rolling and hilly, rather than mountainous.

'Similar quartzites and shales continue up to this point, with the exception of one small exposure of a coarsely crystalline basic intrusive rock on Yahk River.

Head of Gold Creek.

'On the north side of Yahk Mountain, a steep descent leads to the head of the main branch of Gold Creek. An old and rather faint trail was followed down that stream, leading back to the main trail near Plumbob Creek. Quartzites and shales are exposed at intervals all the way, with uniformly low dips to the north-east.

Cranbrook to Moyie Lake.

'Returning directly to Cranbrook, and having secured additional supplies, the next trip taken was southward, to Moyie Lake and thence along the line of the Canadian Pacific Railway as far as Creston, near Kootenay Lake. This was the route followed by the Dewdney trail. Running due south from Cranbrook, it passes over a gently-rising flat-topped hill with an elevation of 350 feet above that place, and descends Peavine Creek, a small tributary of the Moyie River to the Lake.

Basic intrusive rock.

'On the top of this hill there is a considerable area of dark basic intrusive rock, varying in character from place to place. Quartz veins up to two feet and a-half in thickness are found in these rocks, showing a little galena and chalcopyrite (copper-pyrites). Several mining claims have been staked out here. On two of these properties, the Black Bear and the Union Jack, some development work has been done, without so far showing any body of ore that could be profitably worked. Most of the intrusive rocks that were so frequently met with throughout the remainder of the country visited during the season, are of much the same character as these, and are of great significance, being directly connected with the occurrence of mineral veins. They will require to be microscopically examined for determination. Some-

times they occupy extensive areas and in other cases appear only as narrow dykes, but in whatever form they occur, the discovery of deposits of valuable minerals may be hopefully expected in their neighbourhood. British Columbia—*Cont.*

'Moyie Lake, is the name given to two bodies of water, three and a-half, and two and a-half miles long respectively, running southward and connected by a narrows a mile and a quarter in length. The exposures along the lake show greenish argillaceous shales and black slates, with light-gray quartzites. Moyie Lake.

'Moyie is a prosperous new town situated on the lower part of the lake and on the line of the Canadian Pacific Railway. On the mountain to the east of, and just above the town, the St. Eugene and Lake Shore groups of mining claims are located. A good account of the development on these properties is given by Mr. W. F. Robertson, Provincial Mineralogist * and this need not be repeated here. The dyke along which these claims are located and which is associated with the deposit of fine-grained galena constituting the ore-body, is in some places composed almost entirely of an altered pyroxene, but varies considerably from place to place. It is apparently of more recent origin than the basic intrusions previously mentioned.

'Moyie River, leaving the lake, flows south-westward across the Boundary line, a distance of twenty-four miles in a straight line. The railway follows its north-western bank as far as Rainy Creek, between Yahk and Goatfell stations. Along this part of the route several areas of dark-green intrusive rocks break through the country-rock of massively bedded quartzite. Similar rocks continue westward along the line of railway to Goat River and down that stream to the Kootenay River, where grayish-green schists are found interbedded with thin gray quartzites. This is the first instance seen where the rocks have suffered any great amount of squeezing. Moyie River.

'Kitchener is situated on Goat River where the railway first reaches that stream. On the hills to the south several mining claims have been taken up that show good samples of galena and copper ores.

'Goat River was ascended for a distance of twenty miles above Kitchener, to which point a trail had been cut out. This trail is intended to reach the White Grouse mining camp. It was being rapidly pushed forward at the time of our visit. The rocks seen on Goat River consist of thick beds of quartzite with one or two bands of black slate (probably true argillite). Two areas of basic intrusives were seen cutting these near Leadville Creek. Trail to White Grouse camp.

* Annual Report of the Minister of Mines, B.C., 1898.

British Columbia—*Cont.*

'The mountain-ridge running northward from Goatfell station and forming the boundary line between east and west Kootenay, proved to be composed of similar beds of quartzite with one wide band of black slate. The general dip is to the north-west at an angle of 45°. Numerous veinlets of white quartz and specular iron cut these rocks at right angles to the line of strike. Around the head of Kid Creek on this watershed, where the quartzites are somewhat disturbed and folded, larger irregular veins of rusty quartz were seen.

Palmer Bar Creek.

'Returning to the head of Moyie Lake, the railway line was followed northward from there for a distance of about five miles to Palmer Bar. The place so named is where some shallow bench-diggings have been worked for placer gold, and the small tributary of the Moyie River flowing through it is called Palmer Bar Creek. The gold found here does not appear to have been locally derived, but to have been concentrated from the glacial drift coming from the direction of the lower part of Perry Creek. A number of mining claims are located on the north fork of Palmer Bar Creek and on one of them, the Belleville, a good deal of development work has been done, showing a little galena, zinc-blende and iron-pyrites in a gangue of quartz and calcite. The rocks in this vicinity are gray quartzites, in thick beds, and black slate cut by basic intrusives.

'From Palmer Bar a trail runs south-westward through a gap in the hills to Nigger Creek near its junction with the Moyie River. The distance is three and a half miles, and the summit of the gap is 500 feet above the railway line.

Nigger Creek

'The Pay-roll mine is situated a third of a mile north of the crossing of Nigger Creek. A dyke of dark-green intrusive rock, probably a diorite, running northward, cuts the flat-lying massive beds of gray quartzite. A vein of quartz five feet wide follows the contact on the east side of the dyke for some distance and then cuts through the quartzites. This is exposed in a tunnel a hundred feet long and shows good evidence of continuity. It carries galena and iron-pyrites

Telluride.

seams of talc-clay, and is said to assay well. A small vein on another part of this property, cutting across the dyke, showed, in a specimen examined by Dr. Hoffmann, rust-stained quartz, carrying a little telluride of lead (altaite) and some particles of free gold. The specimen is undoubtedly rich in gold, and although there was no gold in the specimen of telluride actually examined, the presence of altaite affords reason to anticipate the discovery of some of the tellurides of gold with which it is frequently associated.

Weaver Creek.

'Moyie River, below the mouth of Nigger Creek, runs for a couple of miles through a cañon that is impracticable for a roadway. Above

that point the valley is wide and deeply drift-covered. The lower terraces and sides of the stream have been extensively worked for gold, and some mining has been done on the upper tributaries. One of these, Weaver Creek, judging from the amount of work done, must have yielded a considerable amount of gold. British Columbia—*Cont.*

'Perry Creek, a tributary of St. Mary River, was next visited. It drains a portion of the Purcell range of mountains lying between the upper part of Moyie River and the St. Mary River. A trail runs north-westward from Cranbrook, following a slight depression in the low hills, to Booth or Six-mile Creek, near the mouth of Perry Creek, a distance of six and a-half miles. It then turns to the south-west and follows up Perry Creek. Old Town, the chief camp on this stream in the placer-mining days, is five miles above Booth Creek. Cranbrook to Perry Creek.

'The first exposures seen along this trail consist of black slaty shale and impure quartzite, both somewhat disturbed. About half way to Booth Creek the effect of pressure becomes apparent in the rocks. Where this was first noticed, in alternating beds of shale and quartzite, the shade has assumed a schistose structure while the quartzite is only partly crushed. Farther on, between Booth Creek and Old Town, the rocks are completely altered to greenish schists. There is very little quartzite in these rocks. They appear to have been originally of the same character as those seen along the upper part of Moyie Lake, but the latter have remained comparatively unaltered. Along Perry Creek, above Old Town, greenish and gray, thinly-foliated sericitic schists are found nearly to the head of the stream. No trace of the original bedding can be seen in these. The pressure exerted upon them has been applied in an east-and-west direction. The rocks on the mountains around the head of the stream do not show the same extreme alteration as those lower down the stream. They consist for the most part of banded gray quartzites and gray quartz-mica-schist. Schistose rocks.

'The lower part of Perry Creek appears to have yielded some placer gold, but the greater part of the gold has been derived from two miles of its length above Old Town. Two miles above Old Town there is a high fall on the stream. At this place, in the erosion subsequent to the filling up of the valley with detritus, the stream sought a new channel across a zone of intrusive rock crossing the creek, leaving the old channel above deeply buried. Farther up the creek, shallow diggings beside the stream have been worked to bed-rock. The surface of the latter is very rough and uneven, and the pay dirt was "pockety". An effort was made to bottom the creek at "Old Shaft," six miles above Old Town, but apparently without success. Placer diggings.

British Columbia—*Cont.* Quartz veins.

'A number of small quartz veins are seen on Perry Creek, cutting the schists at right angles, and three or more large veins, eight to forty feet in width, run for a long distance along the west side of the valley, striking nearly parallel to the creek in the same direction as the schists. The mineral claims on the creek are described in Mr. Robertson's report already referred to, and an account is there also given of the operations of a small stamp-mill testing some of the rock from the large veins. From the report and from what was learned in the field, it seems evident that there was something wrong about the treatment.

Low valley to Palmer Bar Creek.

'On the return journey to Cranbrook, the low valley running from Old Town to Palmer Bar Creek was examined. This was probably a former channel in pre-glacial times, and was possibly the source of the gold at Palmer Bar. It is now blocked up by moraines. About the middle part of its length there is a chain of lakes. The southern one is a mile in length and discharges into Palmer Bar Creek. Gray quartzites, black slates and greenish schists are exposed along the valley, and one zone of light-coloured coarsely crystalline granitic rock crosses it. This seems to be connected with an area of basic intrusive rock exposed for some distance along the railway line south of Cranbrook.

St. Mary River.

'A good wagon-road runs northward from Cranbrook to the St. Eugene mission, a distance of five and a-half miles, where there is a bridge across the St. Mary River, and then continues up that stream. The St. Mary River empties into the Kootenay at Fort Steele. Its sources are forty-five miles to the west, along the watershed opposite Crawford Creek. It is a large stream too deep and swift for fording during the summer months. St. Eugene mission is about eight miles from Fort Steele. Mark Creek flows into the St. Mary from the north, at Marysville, eleven miles above the mission. For the first eighteen miles of its length, the St. Mary has cut out a flat-bottomed valley, two hundred feet and more in depth, through the gravels and white silts forming the gently rolling surrounding country. This was part of the original bottom of the Kootenay valley. Above this the foot-hills begin to close in upon the river, and before St. Mary Lake (twenty-two miles from the mission) is reached, the river is confined between high and steep mountains. St. Mary Lake occupies the bottom of the valley for about two miles. It has been formed by the filling up of the valley at its foot by the delta deposit of Hell-roaring Creek, a tributary from the south. Nine miles above the foot of St. Mary Lake, the South Fork or Baker Creek comes in from the southwest. A trail ascends this branch for eleven miles, then turning up a western tributary called Redding Creek, it crosses the Hooker Pass

and descends Crawford Creek to Pilot Bay. About seven miles above the South Fork, the main stream divides into three branches, the East, North and West forks. All these branches drain high rugged snowy mountains. Another trail to Pilot Bay follows the West Fork and crosses the Sawyer Pass to Crawford Creek. British Columbia—*Cont.*

'Between Cranbrook and the mission, rusty decomposed schist, greenish felspathic schist and dark-blue rather flaggy limestone are exposed. The limestone is somewhat dolomitic and some of the beds in this locality would yield good lime. Another exposure of limestone occurs about two miles east of the road-crossing of Luke Creek. It is here associated with black slates and gray schists, both of which appear to contain more or less volcanic ash. These rocks are like those seen along the railway line between Cranbrook and Fort Steele Junction, and are supposed to be of Carboniferous age. Limestone.

'Around Luke Creek, a small tributary of the St. Mary seven and a-half miles above the mission, rusty black slates with some thin beds of quartzite, are broken through by a number of masses of basic intrusive rock, probably diorite. The latter in some places has a rough appearance of bedding, probably due to its being forced up between the beds of slate. Many mining claims have been taken up in this vicinity, and considerable development work has been done. Several good looking bodies of ore are uncovered, showing galena, tetrahedrite, (grey-copper), copper-pyrites, iron-pyrites and zinc-blende.

'The town of Kimberly is situated four miles up Mark Creek. A railway is under construction at the present time to connect this place with the main line at Cranbrook. The chief object of this line is to carry out the ore from the North Star mine. This property is located on the hill west of the town. It is at a height of 1,560 feet above Kimberly, from which it is about two miles distant in a straight line. The character of the ore-body in the North Star is somewhat peculiar. A description of the property by Mr. W. A. Carlyle,* gives the extent of the deposit as discovered in the shafts and tunnels at the time of his visit. Since that time, the development work has been greatly extended. The country-rock has the appearance of a rather dark, fine-grained quartzite, but a specimen examined by Mr. A. E. Barlow, proved to be a gabbro-diorite. It will be necessary to examine further specimens. It is in thick beds dipping S. 70° E. at an angle of 20.° A zone of this rock running north-and-south, in which the ore-deposit occurs, has been much altered. It is more or less impregnated with iron throughout, North Star mine.

* Report of the Minister of Mines, B. C., 1896.

British Columbia—*Cont.*

weathering rusty where exposed. The ore is solid, fine-grained galena, carrying a small percentage of zinc-blende. In some places a mixture of zinc-blende and iron-oxides is found. Near the surface the ore-body dips with the country-rock, and in some places lines of bedding in this direction can be distinguished. It has a depth of thirty feet and its limits in a lateral direction have not yet been reached. Farther downward and eastward the dip is steeper, and there is evidence of some slipping and displacement of an irregular character. The deposit appears to have resulted from the replacement of the stratified beds by ore. Deposits of this nature are not uncommon, but the replacement is generally confined to the neighbourhood of a line of fracture or vent, so that the deposit has in some degree the form of a vein. In this case, however, the action has extended laterally for a comparatively great distance, and so far no vent has been discovered. As there is little doubt that the mineral forming such deposits comes from below, finding its way upward along a fissure or fractured zone of rock, the discovery of such a passage-way may be looked forward to in this case, with a reasonable hope that it will constitute a valuable ore-body in itself. In the meantime and for the purpose of immediate development, a determination of the lateral rather than the vertical extent appears to be the most important.

Sullivan mine.

'A little over two miles distant, in a direction N. 15° E. from the North Star, across the valley of Mark Creek, the Sullivan mine is situated. The deposit here is similar to that at the North Star, but, as far as the present development shows, it is on a smaller scale. The extent of the deposit over a considerable area is shown by several shafts and open cuts. It seems likely, however, that there are here two or more distinct bodies of ore separated by areas of altered country-rock. The ore is found in the same altered zone of rock that appears to extend all across the valley, and the lines of bedding can be clearly seen in the ore itself. To the north of the mine an exposure shows the country-rock to be a dark-gray quartzite, dipping to the north-east at an angle of 25°, underlain by a bed of brownish, crystalline, arenaceous limestone. Between this exposure and the principle opening on the lode, there is a dyke of dark-green pyroxene-rock, similar to that seen at the St. Eugene mine. It appears likely that this dyke may have relation to the lode, although such relation has not so far been made manifest. There are several other mineral claims in the vicinity of Mark Creek that were not visited.

Rocks around St. Mary Lake.

'Along the St. Mary River there are few exposures to be seen until St. Mary Lake is reached. The quartzite series of rocks, including some beds of black slate and shale, continue, but are broken through by

several areas of basic intrusives. For some distance below and above the lake, the hills on the north side of the valley are composed of a dark, igneous rock, probably diorite, with a band of quartzite near the head of the lake and others showing on the mountains to the north. On the south side, the sedimentary beds seem to be more continuous. Similar conditions prevail to a point about three miles west of the junction of the South Fork. Notwithstanding the great quantity of intrusive rock cutting the sedimentary beds, no great pressure has been exerted upon the latter, as there is no folding nor any appearance of a schistose structure. They are usually rusty and break into angular blocks. The beds are only slightly tilted, and their low dips are fairly uniform, regardless of interruptions. Many mining claims are located in the mountains north of the lake. In Pyramid Basin, seven miles to the north-west, fourteen claims have already been surveyed. British Columbia–*Cont.*

'Farther to the west, on both the South and West forks, extremely altered rocks are found all the way to the summits. These consist chiefly of greenish talcose schist, light-gray and lead-gray sericitic schist, micaceous argillite and some highly quartzose schist. The general attitude of these rocks is vertical, striking north-and-south. The original bedding cannot be clearly distinguished, but there are some indications of an easterly dip at an angle of 25°. This would place them conformably below the rocks previously mentioned to the east, and in the lower part of the Cambrian formation, a position that their character also indicates. Lenticular veins of quartz frequently occur and larger viens are found cutting these rocks in many places. The ore usually occurring in these veins is chalcopyrite, notable deposits of which are found on the upper part of the West Fork. While time would not permit a visit to these properties, an idea of their importance was gathered from seeing a boulder of ore eighteen inches in diameter, carrying a very high percentage of chalcopyrite, that had been brought down by a snow-slide. Schistose rocks.

'In regard to the age of these quartzites, slates, shales and schists, so frequently mentioned and covering such a large tract of country, there is little positive evidence, but they are all, at least provisionally, referred to the Cambrian. The great thickness of these beds can, with some degree of assurance, be separated into three divisions of that age, although there is not sufficient detailed information to draw the actual line of demarcation between them. The great amount of metamorphism that some parts of these rocks have undergone, and the comparatively unaltered state of others, depending as it does upon their situation rather than upon their age, greatly increases the diffi- Age of rocks.

British Columbia-*Cont.*

culty of such division. The upper part of the formation is, however, apparently represented by the rocks occurring on Gold Creek and Yahk River. Some newer beds which are not distinctly separable may be included in the Cambrian. The middle part of the formation consists of the thick beds of quartzite with wide bands of black slate interbedded. These are best seen along the mountain range west of the Moyie River and on Goat River. The rocks of the lower part are most extensively developed on the upper part of the St. Mary River.

East side of Kootenay River.

'On the east side of the Kootenay River there is a strip of country three or four miles wide, composed chiefly of stratified gravels and yellowish-white silt. At the back of this a slight depression runs along the base of the steep slopes of the Rocky Mountains parallel to the Kootenay River. This was clearly distinguished from near the mouth of Bull River to a point beyond the upper part of Lewis Creek, eighteen miles north of Fort Steele, and in an outlook from a mountain, it was seen to extend far beyond to the north-west. This depression or valley probably marks a line of fault, but as there are practically no rock-exposures, it cannot be explained in this way with any certainty. Portions of its length are at present drained by many different streams, but it appears to have been at one time occupied by a continuous stream. A characteristic feature of the valley is that the small streams flowing into it from the mountains, sink in its porous gravel bottom and are lost to sight for long distances, reappearing in springs or lakes.

Bull River.

'Around the mouth of Bull River and Little Bull River there are exposures of bluish-gray limestone, similar to and forming part of the same area as that occurring on the west side of the Kootenay below Wardner. This limestone has been noted by Dr. Dawson in his report on the Rocky Mountains,* where a general description of the eastern side of the Kootenay valley is given. Nothing beyond what is there stated could be learned as to the extent of an igneous intrusion of felspar-porphyry that crops out near Bull River.

'The range called "The Steeples," running north-westward from Bull River, is composed in the lower part, of light-gray quartzites. These are much lighter in colour than any previously met with, but it is probable that, like the thick beds in the western part of the area, they are referable to the middle part of the Cambrian. Overlying the quartzites, near the top of the range, is a great thickness of purple, slightly dolomitic quartzite, gray fine-grained dolomite, slightly crushed, and two bands of rather crystalline, dark calcareous rock containing a

* Annual Report, Geol. Surv. Can., Vol. I (N.S.), Part B, 1895.

good deal of quartz. These beds may represent the Castle Mountain group of Mr. McConnell. Their general dips are to the north-east and north. They come down to the base of the mountains near Lost Creek, half-way between Bull River and Wild Horse Creek, and a couple of miles north of that place, they again recede from the front of the range and become confined to its higher parts. British Columbia—*Cont.*

'At the end of The Steeples range, a few miles up Bull River, the Chicamon-stone mineral claim is located on a dyke of dark-gray porphyritic felspathic rock. The gray slates forming the country-rock are highly altered and the dyke-rock shows a slight schistosity parallel to the cleavage of the slates. The ore, specimens of which have been examined by Dr. Hoffmann, consists chiefly of tetrahedrite (gray copper), with small quantities of intermixed gangue of quartz and a little felspar. In some places copper-pyrites forms an appreciable part of the ore. A coating of erythrite (cobalt-bloom) and small quantities of magnetite are found in some fine fissures. The ore-body, though not very wide as far as yet uncovered, is of a promising character. The dyke on which this claim is located, extends a long distance across the river to the east, and other claims have been staked out upon it. Chicamon-stone mine.

'Wild Horse Creek, flowing in a general direction of S. 25° W., empties into the Kootenay River at Fort Steele. It has a length of about twenty-five miles and drains the greater part of the rugged mountainous country between the upper part of Bull River and the Kootenay. Gold was first discovered on this stream in 1864 * and since that time placer mining has been continuously carried on. Of late years operations have been chiefly confined to hydraulic working. Three hydraulic plants are at work at the present time, two of which are owned by a Chinese and one by an English company. The bottom of the channel on the lower part of the stream has never been gained, although some attempts have been made to reach it. At the present time an effort is being made to discover an old channel, supposed by some miners to exist to the east of the present channel and to be covered up by the steep talus-slope of the mountains. Wild Horse Creek.

'The greater part of the rocks seen on Wild Horse Creek are black slates, striking north-and-south with high dips to east or west. Near the "gap" of the stream, greenish and gray thinly-foliated sericitic schists are found, interbedded with black calcareous schists and dark flaggy limestone. A little to the south, on Maus Creek, greenish chloritic schists occur in great thickness, with bands of black

*See Annual Report Geol. Surv. Can., Vol. I (N.S.), p. 152 B., 1895, for history of earlier workings.

British Columbia—*Cont.*

slate and a few beds of quartzite. The relation of these beds to those found in The Steeples may become clearer when the observations are plotted, but at present it can only be said that from their characteristics they appear to belong to the lower part of the Cambrian. Small quartz veins are numerous in these rocks and during recent years many larger veins have been discovered. Mining claims on some of these veins have been already considerably developed and show rich looking copper ores. High values in gold are reported in some cases. These properties were not visited, but from what could be learned, the veins are in, or in the neighbourhood of, masses of dark intrusive rock. To the west of the hydraulic workings, on the terminating ridge of the Hughes range, in a quartzite dyke, a large vein of rusty quartz is uncovered. It carries a little galena, and it is reported to contain some free gold.

Quartz veins.

Four-mile Creek.

'The first stream from the mountains north of Wild Horse Creek, is called Four-Mile Creek. The head of this stream reaches the valley at the base of the mountains by a short, rapid descent, and turning southward along this valley most, if not all of it, shortly disappears. A mile or so farther down it reappears with increased volume and flows to within a couple of miles of the Kootenay River, where it again sinks, and there is nothing seen below this to indicate its course. Grundy and Tracy creeks come from the mountains at points distant eleven and twelve miles respectively, in a straight line from Fort Steele. They sink in the same manner, but reappear farther down, as a stream called Six-mile Creek, which thence flows continuously to the Kootenay. The little town of Tracy is situated at the "gap" of Tracy Creek, about four miles back from the river. Its existence is explained by the number of mineral claims in the vicinity. These are located principally on Tracy Creek, but there are many others along the edge of the mountains both to the north and south. Some locations on the upper tributaries of Wild Horse Creek are also reached from this place.

Other streams

Tracy Creek.

'The rocks on Tracy Creek consist chiefly of light-gray quartzites and black slates, with some greenish chloritic schist. Near the vein of the Estella mine, in the basin of Tracy Creek, there is a dyke of coarse felspar-porphyry that contains finely disseminated crystals of iron-pyrites. It is similar in character to that seen at Bull River. Other dykes, highly siliceous, are found on the mountains around the basin. In the edge of the mountains south of Tracy Creek there are two areas of dark basic intrusives, similar to those so frequently met with on the other side of the Kootenay. The ores in this locality are

chiefly galena, tetrahedrite and copper-pyrites. On one claim belonging to the Estella group a good deal of ore has already been taken out. British Columbia–*Cont.*

'Near the close of the season, some further work was done to the east and south-east of Cranbrook. Two additional areas of amygdaloidal volcanic rock were found. One of these is on the northern half of Baker Mountain, and the other lies to the south, on the head-waters of Joseph Creek, These rocks are very similar to those found along the Kootenay River near the Boundary line, and are classed with them in the Tertiary. The amygdules in the rock on Baker Mountain frequently contain specular iron, and there are irregular seams of the same mineral seen in several places, up to six inches in width. Some agates were also noticed. The north side of Baker Mountain is composed of thinly-bedded, dark, calcareous and siliceous shales, interbedded with fine-grained bluish limestone and some beds of rather coarsely crystalline dolomitic limestone. These rocks continue westward and join the area of limestone south of Wardner and are included with it in the Carboniferous. Areas of volcanic rocks.

'The wide valley of the Kootenay and the branch valley running past Cranbrook to Moyie Lake, are deeply covered with superficial deposits. There is an extensive development of yellowish-white stratified silt up to an elevation of 3100 feet above sea-level, irregularly interbedded with gravels in some places. Above this, coarse imperfectly stratified gravels are found for a couple of hundred feet, and higher up on the slopes of the hills irregular morainic ridges and hills with numerous pot-holes. Gravels and silts.

'The recent development of lode mining, aided as it has been by the construction of the Crow's Nest Pass Railway, has caused a considerable influx of people to this district. So far the attention of this increased population has been directed chiefly to mining, while the other resources of the country have not been correspondingly developed. Attention may well be drawn to some of these.

'As a source of wealth the timber of this district must be considered as second only to the mines. With the exception of the comparatively small areas of prairie land, before mentioned, the whole of the low country in this district is covered with an open growth of large trees. The absence of underbrush has preserved them from destruction, as fire does not gain sufficient headway in the grass to attack the large trunks. The principal trees suitable for making lumber are Douglas fir and the western larch *(L. occidentalis)*. The latter attains its largest growth in this district. Bull pine (*P. ponderosa*) is also fairly abundant. As yet there has only been sufficient timber taken Timber.

British Columbia—*Cont.*

out to supply immediate local demands. The railway now built, giving easy access to Alberta, should afford a means of reaching a market for an increased output. Although the lack of convenient waterways is some drawback, this is compensated by the facility with which the timber can be hauled out, on account of the open character of the woods. In the higher valleys and on the mountain slopes spruce is abundant.

Agriculture.

'The agricultural industry is still, considering the opportunities, in a backward state. The chief product at the present time is hay. A great part of the Kootenay valley would make rich farming country, but the amount actually available for cultivation is limited by the water supply, as with the exception of bottom-lands along streams and a few favourably situated localities, the ground requires irrigation. On some of the higher grounds there is a danger of summer frosts. Grain and vegetables have, however, been successfully grown at so many widely separated localities, that this industry may be expected to give profitable employment to a great number of people. It is, however, when taken in connection with the raising of cattle that the best

Fruit.

results will be obtained. The rich growth of grasses in the open woods, including the nutritious bunch-grass, together with the shortness of the season during which cattle need to be sheltered and fed, are sufficient reasons to encourage greater efforts in this direction. Apples have been grown for some years at the mission, at Norbury Lakes on Little Bull River, and probably at other places that were not seen. It is worthy of mention that, on Wild Horse Creek, at an elevation of 3,700 feet above sea-level, Mr. Griffith has a small orchard, and some trees, said to have been planted in the year 1874, are still bearing fruit.

Climate.

'A description of the climatic conditions that prevailed during the past season would be very misleading, as they were at variance with the usual conditions, as evidenced by the vegetation and forest growth. These show that the valley of the Kootenay has only a light rainfall during the greater part of the summer months. There is, however, undoubted evidence of an increased precipitation during recent years. The most distinct proof of this is the dead fringe of trees around the borders of lakes having no outlet. In dry countries where thinly scattered trees have attained a large size, the moisture is so taken up by the roots of these, that a young growth cannot usually obtain a foot-hold except where an old one has died. In this country, however, in many places, some young trees are springing up while the old ones are still all alive. This may be considered as further evidence of an increased rainfall. The eastern side of the valley

along the base of the mountains, seems to escape frosts that in the spring and fall are felt at places of the same elevation on the western side. A possible explanation of this is that the unequal temperatures at different elevations in the high mountains so near by, keep the air in motion and prevent excessive cooling by radiation, which, on clear, calm nights results in frost in the comparatively level country on the other side. The most favourable spots, at high elevations, are on the sloping sides of sheltered valleys, some distance above the bottoms. In such places, especially if they have a southern exposure, and there are no snowy mountain-slopes immediately behind, fruit can be successfully grown.' British Columbia—*Cont.*

MACKENZIE DISTRICT.

In the winter of 1898-99, Dr. R. Bell was occupied with office work. In the spring he was directed to explore Great Slave Lake, to which region a number of prospectors had found their way in 1897 and 1898 and from which many specimens of lead and copper ores had been brought out. The discovery of gold in payable quantities had also been reported and special interest in the region was being shown by the people of Edmonton and other adjacent parts of the North-west. Work by Dr. R. Bell.

A specimen of galena brought from the vicinity of the lake and assayed in the laboratory of the Survey in the autumn of 1898, contained silver at the rate of 38·86 ounces to the ton of pure galena. A number of specimens received during the following winter from Mr. W. J. McLean and from Inspector Routledge, N. W. M. P., showed galena, iron-pyrites and copper-pyrites. Thirteen were subjected to assay, and of these five proved to contain traces of gold, and five small quantities of silver.

While Dr. Bell's observations fail to confirm much that had been currently reported, they will be read with interest, and several facts brought to light, appear to the writer to indicate the probability of important discoveries in the future. Dr. Bell's preliminary report on this work is as follows :—

'The object of my field-work in 1899 is stated in your instructions dated 22nd of May as follows : "The late discoveries of metalliferous ores in the vicinity of Great Slave Lake, including gold, silver, copper, lead, &c., appearing to be of importance, it seems desirable that we should obtain some knowledge of that region, which has remained practically unknown geologically and to a great degree geographically." On receipt of these instructions, preparations were made for carrying out the work. Two reliable voyageurs, who had accompanied me on Instructions and preparations.

Mackenzie District–*Cont.*

many previous expeditions, were engaged at Sault Ste. Marie and two other men were subsequently hired at Edmonton. Supplies were ordered from the Hudson's Bay Company at Edmonton, to be immediately forwarded to Fort Resolution on Great Slave Lake, and two wooden canoes were purchased by telegraph at the same place and sent by wagon to Athabasca Landing on the river of the same name.

Assistant.

'It was arranged that Mr. J. M. Bell, M.A., who had been with me in 1896 and 1898 should accompany me as assistant and that if it were found desirable he should remain in the country all winter and continue the exploratory work next spring.

Arrival at Great Slave Lake.

'Having completed our preparations, I left Ottawa with my assistant on the 21st of June and after several unavoidable delays on the way, amounting in all to nine days, reached Fort Resolution, on Great Slave Lake, on the 20th of July, having, therefore, occupied only twenty days in actual travel from Ottawa. At the time of our arrival the ice had not all disappeared from the north-eastern part of the lake, which was our destination, the steamer *Ethel*, as we afterwards learned, having been detained ice-bound in that quarter during the whole of the 21st of July.

'On the way down and at Fort Resolution we met considerable numbers of men returning from prospecting around Great Slave Lake, after having failed to find any indications of the precious metals or of any kind of ores or other minerals of economic value. The exodus continued all summer, several parties of disappointed prospectors ascending the Slave and Athabasca rivers in company with myself at the close of the season.

Plan of work.

'The plan adopted for carrying out the work was for myself to proceed from Fort Resolution north-eastward to the extremity of the lake, surveying Christie and McLeod bays, which form the greater part of the lake in that direction, and also the north-western shore, locating as many of the islands as possible. At the same time, I sent my assistant to make an exploratory survey, geographical and geological, of the Fort Rae arm of the lake, including Yellow-knife Bay. His work connected with my own among the islands about midway across the main lake, opposite this arm. My party consisted of the two men hired at Edmonton and one of the voyageurs from Sault Ste. Marie, while my assistant had with him the other voyageur and a local man named William Brown.

Surveys and observations.

'In making my track-survey of Great Slave Lake to the north-east of Fort Resolution, I used a row-boat, and having been favoured by calm weather most of the time, the distances were determined

principally by the speed of the boat rowed very steadily through the smooth water, but I also used a floating boat-log. The bearings were ascertained by compass. An observation for latitude was taken nearly every day. I frequently ascended hills near the lake to take bearings and to sketch the shore-lines in all directions. When the bays were wide I went up one side and down the other, taking numerous cross-bearings from one shore to the other. All parts of the survey were found to tally very well. Mackenzie District-*Cont*

'My assistant, with one canoe and the two men above mentioned found his distances by the speed of his canoe, paddled at a regular rate in calm water. After these surveys of the above portions of the lake had been successfully accomplished, I made a similar survey for about thirty miles south-west of Fort Resolution and thence paced the distance for eight or nine miles inland to the locality at which galena had been found among the Devonian limestones. While I was engaged in this work, my assistant made a track-survey of the delta of Slave River and examined the rocks of the lake-shore to the north-east of it. When I left Fort Resolution on September 13 he was setting out, according to instructions, to survey topographically and geologically the shore of the bay to the north-east of the mouth of Slave River. I also instructed him, if the season permitted, to explore and map the details of the shore-line of the north-west side of the lake from near Yellow-knife Bay north-eastward to the beginning of my own detailed work in that direction. I have since received (January 22) news from him of his having successfully completed these surveys, together with his map of the shore-lines. Work by assistant in autumn.

'The southern shore of the south-western part of the lake had been surveyed by Mr. W. Ogilvie, D.L.S., and Mr. R. G. McConnell, of the Geological Survey, and I have obtained from Captain Mills of the steamer *Wrigley* the distances between different points on the opposite shores of this portion of the lake, which he has ascertained by ship's log. Our surveys of the past season, supplemented by the above data, will enable us to construct a fairly good map of the whole of Great Slave Lake. Previous surveys.

'As I found that my assistant would be able to do very valuable work in continuation of that of the present summer, as we anticipated at the outset, if he were to remain in the country till next year, I arranged for him to pass the winter with Mr. F. Gaudet, the Hudson's Bay Company's officer at Fort Resolution. Instructions could be sent there by the winter packet, for his guidance next season. If circumstances permitted, during the winter he was to explore eastward from Assistant left for the winter

Mackenzie District–*Cont.*

Fort Resolution or in the direction of Hudson Bay and to make other explorations if possible, such as one of Buffalo River on the south side of the lake.

Return journey.

'On the morning of September 13, I started up stream from the mouth of Slave River on my return journey in one canoe, with the four men I had brought down with me. On this journey I made a track-survey and a geological examination of Slave River all the way to Athabasca Lake. From this lake we paddled or tracked our canoe up the river of the same name to Athabasca Landing. Thence I came with my party to Edmonton by wagon, and reached Ottawa on November 24.

Animikie rocks.

'The south-western portion of Great Slave Lake, lying between the inlet (Slave River) and the outlet (McKenzie River) is an open sheet of water about 50 miles in width, surrounded by unaltered and nearly horizontal Devonian strata. The north-eastern continuation of the main lake-basin is excavated out of the older Cambrian or Animikie rocks resting in a long physical depression or trough in the Archæan foundation. These strata have a thickness of over 1,000 feet and they are thrown into gentle anticlines and synclines, parallel to the axis of the general trough, in which they lie. They have been deeply eroded along the anticlinal folds and the waters now filling the depressions form the various long and nearly parallel bays into which this portion of the lake is divided. These rocks consist partly of unaltered limestones varying in colour from very light- to dark-gray, drab and red, some times passing into shales, and partly of sandstones, mostly red, coarse conglomerates and red shales, together with thick sheets or overflows of greenstone, generally capping the other strata and presenting long cliffs made up of perpendicular columns or "palisades," overlooking the different bays. We could not ascertain whether all these greenstone cappings belonged to a single extensive overflow or not. Large exposures of greenstone also occur near the level of the lake, which may not form part of any general overflow. A few wide greenstone dykes were seen cutting the nearly horizontal Animikie strata beneath the crowning overflow.

Laurentian.

'The older Laurentian gneiss and granites rise as a sea of half-rounded hummocks to a general height of nearly 1,000 feet all along the north-west side of this part of the lake and also around the north-eastern extremity.

Huronian.

'Huronian rocks, consisting mostly of schists, occur around Yellow-knife Bay and thence to Gros Cap, including some islands in this part of the lake, also on some islands in the vicinity of Fort Rae and

again at the head of Lake Marian, a continuation of the Fort Rae Arm. There is also a hill of schistose rocks which may be classed as Huronian in a channel north-eastward of the entrance to this arm. Rocks which may belong to this series were observed on the south-east side, to the north-eastward of the mouth of Slave River. Mackenzie District–*Cont.*

'Besides the foregoing, certain rocks were met with in the narrows south-east of Big Caribou Island and on the tongue of land separating McLeod Bay from the east bay, which may not belong to any of the foregoing, but may occupy a stratigraphical place intermediate between the Huronian and the Animikie, similar to that occupied by certain rocks of the east coast of Hudson Bay which the writer there called the Intermediate Series. At the above localities they consist of massive light-gray, blue or dove-coloured limestones which weather to various shades of yellow and brown, hard reddish sandstones or quartzites and fine conglomerates, and red and gray "lumpy" jasper or chert-rock. At the east bay, black shale occurs in the vicinity of the massive limestone of this series, and may form part of the same set of rocks.

'The Fort Rae Arm and its continuation in Lake Marian, having a total length of about 180 miles from the centre of Great Slave Lake, lie along the boundary between the Archæan and the Devonian rocks, and the continuation of this line probably runs near the canoe-route, from thence by Lac la Martre all the way to Great Bear Lake. Border of Devonian.

'In the narrow central part between the two sections of the basin of Great Slave Lake above described, there is a geographical interval of separation between the Devonian and the Animikie strata, in which the Laurentian rocks prevail with only straggling links of the Animikie.

'On the south-east side of the lake, the Devonian beds are first seen at a slight rise in the level ground called Little Stoney Mountain, north of Fort Resolution, and again on Moose Island, near the same place. At these localities and at the "lead mine," about thirty miles further to the south-east (to be described further on), the strata consist of horizontal beds of porous gray limestone, without observed fossils. On the shore about twenty miles south-west of Fort Resolution, these limestones are associated with black highly bituminous shales. Along the south side of Fort Rae Arm coarse and fine light-gray sandstones were found underlying light-gray limestones, the two rocks forming cliffs here and there.

'As to economic minerals, no regular veins were seen in the old Laurentian, which are the prevailing rocks in the reported auriferous Laurentian rocks barren.

Mackenzie District–*Cont.*

region of the lake. The quartz, in the irregular occurrences of that mineral in these rocks, was always of the glassy "hungry" character which prevails among them elsewhere. In connection with the reported discoveries of gold in the Laurentian rocks along the north-west side of McLeod Bay, it may be here remarked that after very extensive exploration of similar rocks in nearly all parts of the Dominion by numerous geologists and prospectors during the last fifty years or more, no economic minerals of any kind have ever been discovered in workable quantities, so that this was an exceedingly unlikely field in which to search for gold. I discovered a vein of white quartz twenty-five feet in width, among the jaspery rocks of the Intermediate Series in the tongue of land which separates McLeod Bay from the east bay, but it did not look very promising either. Stains of green carbonate of copper were common on the massive yellow-weathering limestone of the same series in the vicinity of this quartz vein.

Copper ores.

'On the north-west side of McLeod Bay, small interrupted gash-veins or stringers of calcspar are found in the primitive gneiss and granite, and some of them contain nuggets of chalcopyrite, but their occurrence is exceptional or accidental, and they have no economic value. At one locality on the north shore of the bay west of the narrows between Christie and McLeod bays, we detected thin plates of chalcopyrite in some of the joints in the greenstone which gave rise to green copper stains and cobalt bloom.

'No iron ore was found, nor could we hear of the occurrence of any around Great Slave Lake, but some layers of the red shales of the south-east side of McLeod Bay contained sufficient oxide of iron to render them perceptibly heavier than the rest of the rock.

'Some of the unfortunate gold prospectors turned their attention to exploring for mica, but they discovered none, nor could they hear of any of a size or quality that might be of value even under more favourable circumstances as to transport, &c.

No veins observed in Animikie.

'The undisturbed and almost horizontal character of the Animikie series around the lake has not been conducive to the formation of mineral veins therein, and none at all were seen in the whole course of our explorations. But in the Thunder Bay region, Lake Superior, silver-bearing veins occur in nearly horizontal rocks of the same age as these.

Occurence of galena and blende.

'The occurrence of galena and blende in the Devonian limestones at some distance inland from the south-east side of Great Slave Lake, appears to have been known to the Indians for a considerable time. About two years ago they were induced to point out the place to some

white men and a large number of claims have been staked. The locality lies at a distance of about eight and a-half miles south-east from a point on the lake-shore twenty-seven miles south-west of Fort Resolution. The intervening country is low and swampy, but for some distance around the spot where the galena and blende occur, the horizontal beds of gray limestone are sufficiently elevated to afford a considerable area of dry ground and to expose a thickness of about twenty feet of the strata in three little ravines. Several dry sink-holes were noticed in the vicinity of the ore. No fossils were observed. The galena occurs as scattered crystals in the limestone over an area of several acres, but at one place where it is largely mixed with blende, it is concentrated in bunches several feet in horizontal diameter. A shot had been put into one of the largest of these bunches, which enabled us to see a thickness of two feet of the ore, but the actual depth of this mass was said to be four or five feet. The results of a large number of trials for silver made by different assayers was to show that this metal was present only in traces. One assay, out of many which I saw made by Mr. N. S. Potter for the Great Slave Lake Mining Company, of a "crust" which had resulted from a concentration in a cavity by the decomposition of the ore, gave a small bead of silver, but the ore in general cannot be said to be economically argentiferous. Mackenzie District—*Cont.*

'In connection with the question of the possibility of carrying on mining operations at Great Slave Lake, it may be remarked that apart from such considerations as the unfavourable climate, &c., the difficulties connected with transportation over such long distances as must be traversed through an uninhabited country and the remoteness of any metal market even when the borders of civilization are reached, to say nothing of the absence of a local supply of labour, would place mining operations out of the question, except in the case of extraordinarily rich deposits of the precious metals, of the existence of which the geological character of the whole region gives little or no hope. Rich deposits only could be worked.

'The evidences of glaciation are well marked around Great Slave Lake. The general course of the striation is south-westward in conformity with the longer diameter of the lake-basin, but it varies locally, the movements of the glaciers having adapted themselves to the trend of each bay or channel which approximated to that of the general course followed by the ice. Glaciation and shore-lines.

'Old shore-lines, showing former higher levels of the water, were distinctly visible in various parts of the lake. These ancient beaches were found at higher levels in the eastern parts than opposite Slave River, indicating a tilting of the lake towards the west or south-west

Mackenzie District-*Cont.*

accompanied by a greater lowering of the water at the north-eastern extremity.

'I wish to acknowledge our indebtedness to almost every one we met for their willingness to assist us to carry out the objects of our journey. Our thanks are due especially to Mr. F. Gaudet, the Hudson's Bay Company's officer in charge of Fort Resolution, for numerous courtesies, and to Messrs. McKinley, Simpson and Camsell for having twice sent us in their steamer *Ethel* over the open traverse from Fort Resolution to near Gros Cap, which was too wide to venture across in our canoes.'

Saskatchewan District.

Work by Mr. D. B. Dowling.

During the early part of the year, Mr. D.B. Dowling completed the compilation of a map of Lake Nipigon on a scale of one mile to the inch, embodying all the surveys of the former season and those of 1894. He was then employed in compiling and editing, from Mr. Tyrrell's notebooks, a general description of the country to the east of Lake Winnipeg. This, with a report on the Cambro-Silurian rocks of the west shore is now ready for printing. The general map accompanying these reports, including Lake Winnipeg and its vicinity is already in press.

Much of Mr. Dowling's time has also been given to revising and correcting proof of the General Index of Reports from 1863 to 1884 inclusive, the printing of which is proceeding slowly.

Saskatchewan District.

The explorations in the valley of the Nelson River and of parts of the Grass River and Burntwood River, carried out by Mr. J. B. Tyrrell in 1896, covered an area roughly triangular in shape. In order to supplement this and obtain information that could be illustrated by a map-sheet, further surveys were deemed necessary, notably toward the north-west in the area between the Grass River and the latitude of the Churchill River, and southward toward the Saskatchewan and the basin of Moose Lake. Mr. Dowling was instructed to undertake this work during the summer. His report on it is as follows :—

'Leaving Ottawa on June 21, I proceeded to Prince Albert and thence by stage to Fort à la Corne. Here a canoe and some camp outfit had been stored since 1896. These were overhauled and the canoe varnished and patched, when, with two men obtained on the spot, the descent of the Saskatchewan River to Cumberland House was accomplished in two days. Here I was fortunate in finding an Indian whose usual hunting ground lay to the north in the district to be explored. The routes from the south into this country were by two

streams, the Cold River, a tributary of the Churchill heading north of Athapapuskow Lake, and the Burntwood River rising in lakes to the north of Reed Lake. The guide knew the Cold River, so we determined to proceed by that route first and chance finding Indians further north to put us on the route by the Burntwood River. Saskatchewan District-*Cont.*

'To reach the Cold River we passed north-eastward from Cumberland House to the mouth of Goose River on the Sturgeon-weir River and thence through Goose Lake to Athapapuskow Lake. From the north shore of this latter lake a small stream leads through a chain of little lakes about directly north to the height-of-land to Cold River. On Athapapuskow Lake the underlying rocks are Huronian, consisting mainly of greenstones and a few beds of conglomerate, though two or three small masses of instrusive granite forming islands, were seen. To the south and west are found horizontal beds of Trenton limestones resting on these rocks, and on some of the islands on the north-west shore isolated areas of the limestone also still remain. Athapapuskow Lake.

'The Huronian area extends north-west to near the height-of-land, the strike of the beds being mainly northward parallel to our course, but turning abruptly to the east on the upper lake of the chain. The north shore of this lake is found to be occupied by light-coloured granitic gneiss striking to the north-east about parallel to its line of contact with the Huronian schists, which also run in nearly the same direction. The exact contact was not noted, being apparently in the bed of the lake and at the extreme ends of deep bays on either side. Huronian and Laurentian.

'Over the height-of-land, where a portage of a mile was made, we entered by a small stream, a long narrow lake lying along the strike of the gneiss. The surrounding hills are poorly wooded and are generally bare rocky ridges. From this lake, the stream we descended to Cold Lake was not large, but in its lower part occupied a wide channel. On its banks the first terrace of stratified material north of Goose Lake was noticed, being here mostly of sand, while the surrounding country, between the rocky ridges, is covered entirely by a thick growth of Banksian pine.

'Cold Lake, through which we passed, is about twenty miles in length and possibly ten miles wide, though it is so full of rocky islands that the main shores are hard to recognize. A well-defined rocky ridge runs along the east side and continues north until it is broken through by the stream draining this basin. The rocks are generally a light-reddish gneiss with a few bands of a more basic character all broken into by intrusions of a light-reddish pegmatite. On one of the islands in the central part of the lake the intrusive mass Rocks of Cold Lake.

Saskatchewan District-*Cont.*

cuts through beds containing disseminated iron-pyrites. This being oxidized in the vicinity of the intrusion colours the surface of the rock in a broad rusty band across the rocky hill.

'The dip of the beds here being at a very low angle and in some places nearly horizontal, the outcrop is deflected to a great extent by the small undulations.

'The river leaving the lake runs to the north-east until it enters a gap in the bold ridge running along the east side of the lake. Here several heavy falls are passed and an abrupt turn is made to the north from a small hill-enclosed lake-basin. Rough hilly country extends to the Churchill River and characterizes the whole of that valley from west of Duck Lake to below Nelson Lake.

Churchill River.

'An excursion up the Churchill River through Duck Lake to Doctor Lake and return by the main river to the north was also made before proceeding toward Burntwood Lake. Finding a guide who knew the Burntwood River well, we proceeded toward Nelson House by a canoe-route to the north of Burntwood Lake, following down the Churchill River to Nelson Lake and eastward by a long arm finally portaging south to Burntwood River some distance below the lake. Nelson House is situated on a small lake on this river at the confluence of two other streams. Two missions, one of the Methodist church and another of the Roman Catholic church, are established here, and at each, as well as at the Hudson's Bay Company's post, are large gardens containing nearly all the ordinary garden vegetables. At the date of our visit (July 27) potatoes could be found about the size of hens' eggs.

Burntwood River.

'The Burntwood River from the lake to this point, descends through a terrace of sand and clay that begins at the lake a foot or two above the lake level. The river gradually cuts down until its banks become about thirty feet high at Nelson House. As the fall in the river estimated at the rapids closely approximates to this amount, the surface of the terrace is evidently nearly level. The underlying rocky surface is very uneven, but generally slopes to the north-east, so that in descending the stream the terrace deposit covers a larger part of the surface and the protruding hills become less conspicuous.

'The prevailing timber is Banksian pine, with a sprinkling of black spruce and poplar in the valley near the stream. On the level surface behind the marginal part drained by the river, muskeg is reported as occupying a large part of the area. This evidently denotes a lack of drainage, and as the soil is very rich where gardens have been made, there is little doubt that larger areas could be farmed. This applies

only, as far as personal observation goes, to the valley of the Burntwood River and parts of the Churchill River and the vicinity of Reed Lake. Saskatchewan District *Cont.*

'After obtaining supplies at Nelson House, we ascended the stream again to Burntwood Lake. Traversing its entire length, we crossed the Burntwood portage at its western end to the Churchill River and connected our traverse with that down the Cold River and along the Churchill River.

'The rocks encountered along the Churchill River and on Burntwood Lake are mainly garnetiferous gneiss and dark hornblende-gneiss broken into and often paralleled by large dykes of light salmon-coloured pegmatite. The beds are nearly vertical and show the result of great pressure, producing a beaded or lenticular structure. The strike is generally east-and-west, with of course many local deflections, but on the east end of Burntwood Lake and on the river below, the general strike is about north-west and south-east. Rocks of Burntwood Lake and Churchill River.

'From near the middle of the lake we entered an arm leading south in the direction of Reed Lake. This gradually narrows to a stream in places. About half way to Reed Lake we were surprised to find in a little lake-expansion a small outlier of Niagara limestone occupying an island and part of a long point. The beds dip to the north-east. Outcrop of Niagara limestone.

'In Loon-head Lake, north of File Lake, the gneisses, which for some distance north have a uniform strike to the north-west, are succeeded by a broad belt of granite, and immediately southward are found hornblende-schists and a few interbedded bands of granitic gneiss and pegmatite striking north-east, very much contorted and crumpled; but on File Lake these are found to be part of a series of Huronian rocks which, near the contact with the granite, have been to a great extent re-crystallized and bent. The strike of the Huronian rocks of File Lake is about north-north-east and is continued at nearly the same north-and-south direction southward to Reed Lake. Huronian rocks.

'The route followed south was through File Lake to Methy Lake and by a long portage from the latter to Reed Lake. This road was through Banksian pine along the edge of a sand terrace or succession of heavy sand ridges lying to the east of an abandoned valley connecting the two lakes. As we were unable to find the southern route from Reed Lake to the Pas, we returned by the Grass River to Athapapuskow Lake and thence to Cumberland House. File Lake to Cumberland House.

'On the Grass River a few miles below Elbow Lake, several localities were examined and specimens collected from beds that seemed highly pyritized; some quartz veins that had been prospected were also seen,

Saskatchewan District–*Cont.*

but apparently there had been insufficient returns obtained from these surface showings, as the claims had been abandoned. From Cumberland House we went down the river to the Pas and from there started to explore a route leading to Reed Lake. On this route we crossed the Pas ridge north of the Indian reserve at Mr. Reeder's trading post and passed by Atikameg Lake to Pelican Lake. These two lie to the east of the ridge and are both large bodies of water. From the western side of Pelican Lake we ascended a small stream, that takes its rise near Reed Lake, but in its upper part is nearly blocked by willows, and is so small and crooked that our small birch canoe was the only one we could force through.

Garden at Reed Lake.

'On reaching Reed Lake, I visited the home of Mr. Cowan, who has settled there, and found that he had cleared a small patch for gardening, in which he was growing a fine crop of potatoes, cabbage, turnips, beets, beans, and had also a small strip of grain that he expected would soon be ripe. Returning to Pelican Lake, we followed the north shore to its outlet at the east end. This is connected by a wide sluggish stream through a muskeg flat, with the north-west arm of Moose Lake. From our survey of this part of Moose Lake we found that fully half of its area had not been shown on any previous map, the eastern part only being outlined.

Niagara outcrops.

'Several outcrops of the Niagara rocks were visited and a few fossils obtained. On our excursion to Reed Lake, the Niagara rocks were found to extend northward to within a short distance of the lake, leaving apparently a thin exposure of Trenton which outcrops along the south shore.

'The chain of lakes reaching from Atikameg Lake near the Pas ridge to Moose Lake occupies a single basin, as the intervening country is very low, being mostly muskeg and marsh.

Delta plain of the Saskatchewan.

'The trading post at Moose Lake, is situated near the outlet on a limestone ridge north of a wide grass-flat which stretches toward the south-west, and through this the several branches of the Saskatchewan River wind. The southern edge of the wooded country forms a rough line running to the west and along the margin is a series of lakes and ponds by which we returned instead of ascending the main river, although we had a long portage of nearly a mile to make through a grass-flat.

Autumn flood.

'On reaching the Saskatchewan, we found it in flood and steadily rising, an unusual occurrence for the autumn season. Above The Pas the whole country was flooded for many miles. The gardens near the river, as well as all the hay crop, was under water. The half-breed

settlement at Birch River was flooded out and the people were camped on a ridge on the old Indian reserve near by. Finding the country in which I had planned to spend a couple of weeks, in the condition of a large lake with very few camping places left, I determined to pay off the men and return by Lake Winnipeg, the ascent of the river to Fort à la Corne being a long tedious journey. Saskatchewan District—*Cont.*

'Returning to the Pas, we crossed the Birch River portage without lifting the canoe and passed through the gardens of the houses there, which are said to be on the banks of a stream, eight or ten feet above the water. They were submerged to the tops of the windows, and the school building, the highest among them, showed only the upper casement of the windows, the whole basin being apparently filled to the level of the tops of the banks of the Saskatchewan River.

'From Selkirk Island on Lake Winnipeg, I was fortunate in securing passage on a steamer to Selkirk, sending the canoe back to Cumberland House with the men brought from that place.

'The northern edges of the Huronian areas were found at two localities, but the western extension runs probably to Beaver Lake and thence beneath the Trenton limestone which is known to outcrop on its western side. Other small areas probably occur farther west, as Mr. A. S. Cochrane notes serpentine on a little lake south of Pelican Narrows. The small finds of gold in the Saskatchewan in this vicinity can be traced no doubt to the boulder-clay which is derived from the north. Huronian areas.

'Although as yet this district has not been prospected, valuable mineral deposits will probably be found in the near future, and with the advent of railway communication, may become important. In regard to railway projects, the district is situated on the line of the projected road to Hudson Bay and a feasible route by the Pas ridge across the Saskatchewan river-flat leads north through fairly level country underlain by limestone to Reed and Herb lakes, the basins of which are excavated in Huronian rocks. Northward to the Burntwood River rougher country would be met, but the plain through which this stream cuts its valley, offers a possibility for agriculture perhaps not expected in this latitude.' Feasible railway route north.

Ontario.

Mr. W. McInnes employed the winter months in working up the surveys and notes of the preceding summer and in completing a report, which was issued in the summer, on the geology of the area covered by the Seine River and Shebandowan map-sheets. The work of the Work by Mr. W. McInnes.

Ontario—*Cont.* summer was directed mainly to extending the explorations of the previous season in the Rainy River District of Ontario, to cover, as nearly as possible, the geological map-sheet adjoining the Seine River on the north, to be known as the "Ignace" sheet. Mr. McInnes' short report of progress is as follows :—

Assistants. 'I left Ottawa on June 28 and was joined at Fort William by Messrs. T. W. Ellis and E. B. Thompson, who had been assigned to the party as assistants for the summer. They continued with the party until surveying work was finished in the autumn and performed their work satisfactorily.

Method of survey. 'Owing to the absence of any reliable map of the area, it was again found necessary to make surveys wherever explorations were carried on. These were made with a Rochon micrometer telescope and a four-inch, free-needle compass, minor details being added with boat-log and compass. Three Peterborough canoes were used, and four Indians, with the two gentlemen just mentioned and myself, made up the party for the season.

English River. 'The English River was first surveyed from English River station on the Canadian Pacific Railway to Bear Lake, the highest point on the river reached last year. For the first twelve miles below the railway, exposures of rock are infrequent, the river lying in a wide, flat valley, and sweeping from side to side in broad curves through wild hay meadows, with but a narrow fringe of low bushes along its immediate bank and occasional clumps of black spruce and tamarack. The few exposures seen were all of well-foliated, biotite-granite-gneiss.

Keewatin band. 'About twelve miles down, a band of hornblende-schists and fine, black biotite-gneiss or mica-shists crosses the river, striking N. 35° W. With the exception of this narrow band, that has a width of only about half a mile and may represent the remnant of a Keewatin band, biotite-gneisses are met with all the way down the river, the strike gradually changing to north-east. Between the railway and Selwyn Lake, six rapids occur, with a total fall of over fifty feet, necessitating portages aggregating a mile and thirty chains.

Selwyn Lake. 'Selwyn Lake is really a shallow river-expansion, showing many exposures of well foliated, biotite-granite-gneiss striking about north-east. Below the lake the river is wide and lake-like, as far as a series of rapids that mark, the entrance to Mattawa Lake, another expansion of the river much larger than the first. The same gneisses occur all about the lake with the same general strike, well glaciated and showing striæ running S. 10° W. They are irregularly interbanded in coarse and fine layers, the coarser invading the finer and inclosing

blocks of it. The main English River flows out of this lake about half-way down its western side. At its extreme north-eastern end the lake receives the waters of Shikag Lake by a short stream, with rapids passed by a portage of five chains in length. Ontario—*Cont.*

'Although about twelve miles long and varying in width from a few chains to three or four miles where it expands into bays, Shikag Lake is generally shallow, with many protruding rocks and shoals. Soundings in its more open part gave depths reaching fifty-five feet. The immediate shores are low, rising very gradually from the water to the general level of about fifty feet a mile back. The extensive brulé that was found to extend down the English River from a little below Selwyn Lake northward to beyond Brulé Lake, does not reach this lake, where second-growth, green forest of fair size covers the hillsides, with an occasional red pine of the original forest still standing. Rock exposures are frequent about the shores and very uniform in character, consisting of fine, biotite-gneisses similar to those already referred to and with the same strike. To the east, a low watershed divides this lake from the waters flowing into Metionga Lake, which empties by the Bright-sand River into the Albany River. Shikag Lake.

'Continuing down English River from Mattawa Lake, two small rapids are passed and then another river-expansion, known as Wigwaskwa Lake, is reached. Gneisses similar to those already spoken of occur all about the lake, the strike varying from north-and-south to east-and-west. Glacial striæ are well marked running S. 16° W. Wigwaskwa Lake.

'Below the lake the river takes an abrupt turn to the south and keeps that direction for eight miles, to Pine Lake, preserving for the greater part of the distance a lake-like character with an average width of about half a mile. Pine Lake is divided by a long point, about a mile wide, running up through its centre, into two lakes each about five miles in length and from one to two miles wide. The rocks exposed about the lake are the same biotite-gneisses with a less marked foliation and generally contorted. Many of them, in addition to orthoclase felspar, show large crystals of albite. At a few places about the shores, the lake washes against cut-banks of sand with faces from fifteen to twenty-five feet high. One of these sand-covered areas on the east shore supports a good growth of red pine and spruce. Pine Lake.

'Leaving Pine Lake the river flows in a direction a little west of north for seven miles and then turns sharply to the west for four miles, through what is really a long narrow arm of Bear Lake. Rock exposures are not frequent along this part of the river's course; they are all of biotite-granite-gneiss in coarse and finer bands, the dips becoming gradually flatter until, along the shores of Bear Lake, they are nearly Building stone.

Ontario—*Cont.* horizontal, with low undulations, the coarse and fine materials alternating in a stratiform way.

Pagutchi Lake.

'A survey was then made of Pagutchi Lake, lying to the east of Sand-point Lake. The area of obscurely foliated gneisses with horizontal, bench-like jointing that extends for a long distance to the north-west of Ignace, was found to include the rocks seen about this lake. Advantage has been taken of the facility with which this stone can be taken out, at the Canadian Pacific Railway quarry near Ignace. Blocks of almost any dimensions can be quarried with little trouble, and all the bridge-piers and culverts along this section of the railway are being built of it. Pagutchi Lake is about nine miles long, running in a general way north-easterly from Niven's meridian line, but is only from a mile to a mile and a-half wide.

'A route was next surveyed leading from Otter Lake up Minomin River and through Hat, Pine, White Rock and Young lakes, occurring along its course, to Sturgeon Lake. From the railway to Sturgeon Lake by this route makes a good two days' journey. There are eight portages, aggregating not quite two miles of carrying.

Keewatin of Sturgeon Lake.

'The southern edge of the Keewatin band of Minnitaki and Sturgeon lakes, was struck just north of the first portage beyond Hut Lake. At the northern end of the portage, fine, biotite-gneiss striking N. 65° E. incloses rounded pieces of green chloritic schist, resembling a Keewatin rock, and the first exposures seen in Pike Lake are typically Keewatin, consisting of hard, felspathic quartzites and various schists striking N. 75° E. The direction of the glaciation is well marked by striæ trending S. 33° W., swinging to S. 26° W. on Young Lake where they occur on a hard felspathic, schistose rock, that has, in certain layers, a conglomerate structure with the pebbles all small and similarly composed of flinty, felspathic quartzite; probably representing harder bands of the schist, that have been broken and surrounded.

'Continuing towards Sturgeon Lake, the portage crosses a low watershed rising perhaps thirty-five feet and descending fifteen feet, the exposures met with varying from quartzites to diorites.

Soundings.

'Sturgeon Lake lies in a belt of Keewatin rocks, but little wider than the lake itself and made up of the usual, widely divergent types. It is a very beautiful sheet of clear water, with a length of about forty miles and varying in width from half a mile to a mile and a-half. The shore-line is broken by a number of bays of irregular shapes, some of which extend back for several miles. These afford to the prospector a ready means of access to all parts of the Keewatin belt. Soundings near the centre of the wider parts of the lake showed depths

of from 100 to 157 feet. The forest about the lake is still unburnt, except in limited patches, and everywhere there is a thick coating of moss covering the surface of the rocks. The lake is drained by Sturgeon River, which flows from it near the north-western end, and, after following a westerly course nearly sixty miles, joins the English River at Abram Lake below Minnitaki Lake. Ontario—*Cont.*

'All along the long, narrow arm that is first reached on the route from Young Lake, the rocks consist of alternations of coarse, hard diabases, felspathic quartzites and green schists, striking about north-east or parallel to the shore-lines. Where the lake widens out suddenly to two miles and a-half, the south shore is just about at the contact, the rocks consisting chiefly of quartz-porphyries that in certain exposures become quite granitoid, with abundant blebs of opalescent quartz; often crushed and sheared to a schist and generally holding iron-pyrites. Along the south shore, past Drunken Island, and to the crossing of Niven's meridian line, quartz-porphyries that vary to quartzites and hydro-micaceous schists trend parallel to the shore. The northern edge of the gneiss area lies about a mile to the south of the lake, keeping about parallel to the shore-line. Principal rocks.

'On the north shore, the first bay of any considerable size lies entirely within the northern gneiss area and the line of contact crosses about half-way up the next bay. Just to the east of this, however, it bends away to the north, as on a long irregular arm, just west of the meridian line, Mr. Ellis, who surveyed it for six miles with the boat-log, did not reach the edge of the gneisses. Line of contact.

'The lake was examined down to the foot of the narrows, about twenty-five miles from its head. With the exception of the gneiss already referred to as occurring on some of the northerly bays, and of some granitic intrusives in small masses, only Keewatin rocks are seen. Just east of the meridian line the north shore and island show high cut-banks of white, quartz sand. Diorites and green schists extend all along the south shore to the west end of the narrows, where there is an intrusive mass of porphyrite with a groundmass of quartz and felspar, abundantly specked with pyrite, and with large crystals of orthoclase. This rock weathers deeply and is rusty from the decomposition of the pyrite, and waterworn surfaces are thickly covered with projecting felspar crystals, often of large size. Along the narrows, Keewatin diorites, quartzites and schists strike about N. 50° E., and at the lower end is a small area of massive crystalline felsite which becomes in places a close-grained or cryptocrystalline rock composed largely of quartz. Keewatin rocks.

Ontario—*Cont.*
Glaciation.

'The rock-surfaces are generally well glaciated, the striation running S. 15° W. A little to the east of Moose-head Point, a very striking pot-hole, about fifteen feet deep by ten in diameter, is plainly seen in the cliff. About half of the encircling rock has been worn away, leaving a hollow that is known to the Indians as Windigo's back.

Mineralized zones.

'Mineralized zones of sericitic quartz-schists with reticulating and bunchy quartz veins were noted along the lake, and, late in the summer, a number of locations were surveyed on which it was claimed that good showings of free gold had been found. Small working parties were sent in to do preliminary development work with a view to proving them.

'This belt affords a practically new and apparently promising field for the prospector, as very little exploratory work has been done on it and the rocks are of a character that would seem to warrant closer examination. The green forest and the deep covering of moss are unfavourable features, but the easy accessibility of the lake and the extent of its shore-line that lies within the Keewatin belt are strongly in favour of the prospector.

Contact.

'At Blackwater Lake, between Sturgeon and Brulé lakes, the southern contact crosses the lake, the gneisses at the edge merging into quartz-porphyries and cutting massive diorites.

Brulé Lake.

'Southward from here Laurentian banded gneisses extend all about Brulé and adjoining lakes. They are interbanded fine, black and coarse, white biotite-gneisses, the latter invading the former and inclosing pieces of them in the form of broken bands. Along the north shore, closely following its general curve, is a band of very fine biotite-gneiss that probably represents an extremely altered tongue of inclosed Keewatin rocks. About the central parts of the lake, the gneisses show but little foliation and several masses of a very tough, anorthosite-like rock form what seem to be intrusive bosses, making up the body of several islands and a small area on the long, central, easterly-projecting point. The strikes curve gradually from N. 35° E. at the south-west end to east along the eastern shore. The same rocks are continuous southerly down through Cut-stone to Mattawa Lake.

English River to Sand-bar Lake.

'Returning towards Ignace, a route was surveyed from the English River below Pine Lake across to Sand-bar Lake. After ascending Moose River and the two long narrow lakes into which it expands, a portage of a quarter of a mile, the first part up a steep hill-side, leads to Down-hill Lake. About Moose Lakes occasional exposures of

gneiss are seen, generally dipping at low angles and well glaciated in a direction S. 22° W., while on Down-hill Lake, particularly all along its south-east side, are banks of sand and gravel five to fifteen feet in height with no exposures of gneiss *in situ* but with an abundance of large gneiss boulders. Ontario—*Cont.*

'The succeeding lakes, Wabuska (White Grass) and Wabikoba (Willow Narrows), have low shores running back in the form of sandy flats to hills of very moderate height behind. The gneisses are not so distinctly foliated here, and the strike is quite indistinct.

'A portage of sixty-seven chains, over a drift-covered, rolling country, leads to a small lake at the head of Stone Brook, about the shores of which, and down stream to Sand-bar Lake, are occasional exposures of obscurely foliated biotite-granite-gneiss.

'Megikons River, which empties into Pine Lake, was surveyed to its source in some small lakes south of the railway near Tamarac station. Few exposures occur along the lower parts of the river; those that were seen being of biotite-gneiss lying nearly flat. Banks of sand varying in height from twenty-five to ten feet are common along the river, the sand-flats apparently extending back from the river for long distances. The sand is made up mainly of very fine grains of quartz, so fine and so well compacted together in certain layers as to hold up the water and form a line of little springs at its upper edge. The country through which the river flows is a great sandy flat with occasional ridges of sand and gravel. Small Otter River.

'The Gull River, from its source in Gull Lake flows through a country for the most part comparatively level, with large areas of marshy land. Occasional exposures of gneiss crop out, but for long distances the river meanders through a broad flat valley. At a point about twelve miles above the crossing of the Canadian Pacific Railway, the hay-belt that borders the river almost continuously, widens out to form a large meadow with an area of probably two square miles. Generally, below the railway, the river is of the same character, broken by occasional rapids and falls, among which one, about a mile from the railway, is of considerable height; it occurs in two successive pitches with a total descent of over thirty feet. Meadows.

'No actual mining work was being done within the limits of the area explored, with the exception of the preliminary work on Sturgeon Lake, already referred to, and the prospectors were just beginning to reach the Sturgeon Lake belt of rocks. Mining.

'After closing up the season's surveying work and sending Mr. Thompson and Mr. Ellis home, a few days were spent, with Port

Ontario–*Cont.* Arthur as headquarters, in accompanying the Director of the Survey in an examination of the Animikie contacts along Thunder Bay, on the Kaministiquia River and at other points in the neighbourhood. Ottawa was reached on October 19.'

Work by Mr. A. E. Barlow.

During the first part of the year, until the beginning of field-work early in June, Mr. A. E. Barlow, with the assistance of Mr. Joseph Keele, was engaged in plotting and compiling the topographical information secured for the Haliburton map-sheet. This includes not only surveys of roads and railways not shown on the township plans available at the Crown Lands Department, Toronto, but also extensive resurveys of many of the more important lakes and streams, which were either incorrectly shown or omitted altogether on these maps. Some time was likewise consumed in examinations under the microscope of a large number of thin sections, taken as representative of the various rock-types exhibited in this district, while considerable progress was made in the preparation of the report on the geology of this portion of Central Ontario.

Joint report of Messrs. Adams and Barlow.

Dr. F. D. Adams and Mr. Barlow were again closely associated in the field-work necessary for the completion of the Haliburton map-sheet. The following account of the progress of the work includes results obtained by both gentlemen :—

'Mr. Barlow left Ottawa on June 7, joining Mr. Keele (who had preceded him) at Oak Lake. The surveys and examinations were extended southward into the township of Belmont, and thence into Marmora and connection made with the work done by Messrs. Coste and White of this survey in 1886, as shown on the map of the Madoc and Marmora mining district. This extension of the work so far to the south, was necessary, not only to establish with greater accuracy the geographical position of the sheet, but also to correlate definitely the geological observations with those made in previous years by other observers in regions where the Hastings' series had been originally described as typically developed.

General geological results.

'One of the important results thus obtained has been that most of the occurrences of conglomerates previously described are found really to be of the nature of autoclastic rocks, evidencing not only the intricate and extensive intrusion of the plutonics through the associated clastic rocks, but also the pronounced dynamic action to which the resulting complex has been subjected. In addition, it seems certain now, from the result of the past summer's work that the Grenville series is merely a more altered form of the Hastings series as was stated to be probable in a former Summary Report.

'Dr. Adams left Montreal for the field on June 13, going by way of Peterborough and Lakefield into the township of Burleigh. Examinations were made of the western portions of the townships of Cavendish and Harvey, which lie within the boundaries of the sheet. This district was found to be occupied by a southward extension of the Anstruther granites and gneisses with the exception of a very considerable development of crystalline limestone, much of it very pure, in the central portion of Cavendish. This was mapped and its relations to the associated gneisses were determined. Ontario--*Cont.* Cavendish and Harvey townships.

'A detailed examination was then made of the township of Methuen. The great granite area that forms the blueberry barrens was mapped and traced northward into the township of Wollaston, where it ends on the rear of the VIth concession. The nepheline-syenite area mentioned in the last Summary Report was also studied in detail, especial attention being paid to the corundum deposits occur in connection with it. Afterwards the great area of crystalline limestone that extends up from Burleigh and occupies the whole of the district around Jacks Lake was studied and mapped. Cutting through this limestone several undoubted dykes altered by later movement were found. These are of great importance, as they now consist of a rock not to be distinguished from many of the amphibolite occurrences in various parts of the area and whose origin it was very difficulty to determine. As a result it is probable that many of these amphibolites are of igneous origin and presumably of the nature of an altered diabasic rock. Methuen.

'The latter part of July was occupied in examining the very complicated district about Apsley in south-eastern Anstruther and south-western Chandos; the true relations of the limestones, amphibolites and granites being determined by a detailed mapping of the area. Anstruther

'The very rough and rugged township of Lake was explored in the early part of August, and a remarkable series of conglomerates, associated with what is apparently a series of ancient volcanic rocks were discovered to the west of Burnt Lake. The strata of the township of Lake are distinctly of the type of the Hastings series of Vennor and many of them are but little altered. Lake.

'The latter part of August was spent in a study of the township of Wollaston. The several areas of granite and diorite occuring in this township were mapped and their relations to the limestones and amphibolites determined. Another remarkable band of conglomeratic rock, almost certainly of autoclastic origin, was found on lots 16 and 17 in con. IX. of this township. The several bodies of iron ore in the township were also examined and found to be portions of limestone- Wollaston.

Ontario—*Cont.*

amphibolite series, probably resulting from the replacement of the limestone rock by iron-bearing solutions.

Glamorgan and Monmouth.

'Dr. Adams' work on the sheet was then completed by the examination, in September, of the eastern portion of the township of Glamorgan and the south-western corner of Monmouth. A large area of gabbro, often holding considerable amounts of iron ore was found in the south-east corner of Glamorgan associated with a large development of nepheline syenite. This latter rock was traced across lots 22 to 27 of cons. IV. and V. and on lot 30 in con. IV. it assumes a very coarsely pegmatitic development and is rich in sodalite. Nepheline-syenite, as well as a great development of gabbro with iron ore is also found in the south-western portion of Monmouth. The former rock is well exposed on lot 10 in con. III. and lots 2 and 3 of the same concession, where it is rich in nepheline, while the gabbro is well exposed about Pine Lake.

Course of Mr. Barlow's work.

'About the middle of July, the work was carried northward again by Mr. Barlow from the township of Marmora into the township of Tudor. The north-western part of Tudor as well as the south-western corner is underlain by the limestone-amphibolite series, while the Hole-in-the-wall diorite, extending from near the junction of Otter and Beaver creeks in the township of Lake, cuts across the township of Tudor, forming the central and eastern portions. Thence this mass of basic intrusive material extends into Grimsthorpe, giving place eastward to the granites which extend northward through Cashel to Weslemkom Lake. August was taken up in examinations and surveys in the townships of Cashel and Limerick, while September was devoted to a study of the nepheline-syenite and associated rocks in the townships of Faraday, Dungannon, Wollaston and Carlow.

Mines in Belmont and Marmora.

'During the progress of the surveys and examinations in Belmont and Marmora, a preliminary examination was made of a few of the mines and some of the information then acquired may be here included.

Deloro mine.

'The famous Deloro mine, situated in the township of Marmora, a short distance east of Marmora station on the Central Ontario Railway, is now operated by the Canadian Gold Fields, Limited, of London, England, in succession to the old Canada Consolidated Gold Mining Company. The Deloro property itself contains about 525 acres, consisting of lot 2 in the VIIIth concession of Marmora, 10 in the VIth, the west half of 10 and the north-east quarter of 8 in the IXth. Certain options and rights in Marmora and adjacent townships, however, give an area for exploration and development in excess of the area thus described. Operations were commenced under the present company about the middle of September, 1896, and have continued ever since.

Mr. Kirkegaarde is at present in charge of the works. Extensive works for the proper treatment of the ore were erected by the present company at Marmora station, but these were totally destroyed by fire during last spring, and at present all the operations are carried on in the immediate vicinity of the Deloro mine itself. The extraction of gold from the refractory sulphides is accomplished by means of the Sullman-Tweed or bromo-cyanide process. Ontario—*Coal*

'The mines are situated on a belt of rocks which, according to Mr. E. Coste's map of the Madoc and Marmora mining district, are Archæan and igneous, and designated as granite inclosing fragments of Archæan. As far as could be ascertained during our inspection, the rock is a mixture of a dark-gray quartz-diorite cut by a hornblende-granite which ramifies through the diorite often in the most intricate manner. Although at times certain comparatively large areas of granite are differentiated rather sharply against others which have a dioritic facies, occasional masses may be noticed that seemingly mark a transition from one rock type to the other. Such masses consist of a rock of a grayish colour, weathering reddish, more basic in composition than the granite and more acidic than the prevailing diorite. These rocks are cut through by pegmatite dykes that are evidently later and more acidic secretions from the same magma from which the granite and diorite have solidified. Associated with these are certain irregular areas of allotriomorphic quartz, which fill in all the irregular cracks and fissures in the rock. The pegmatitic origin of these quartz veins seems beyond a doubt, as places may be seen where the walls of the vein are pegmatite passing inward towards the centre into the gray translucent quartz and containing the usual sulphides and carbonates. Country-rocks.

'The rocks themselves may be regarded as forming part of a basic border or mantle surrounding and cut through by the large mass of granite known as the Huckleberry Rocks. Mining operations have disclosed the fact that the rock everywhere in the vicinity has undergone rather profound shearing and dislocation, the irregular cracks and fissures being filled by the quartz. These irregular vein-like masses of quartz contain a considerable amount of arsenopyrite (mispickel), some calcite, dolomite and ankerite, a small amount of pyrite, and a still smaller amount of chalcopyrite. Free gold is only occasionally visible to the unaided eye in the quartz, but so finely is this disseminated through the sulphides, that it requires the greatest vigilance on the part of the manager to prevent undue loss. In a rough sorting of the ore which is usually carried out, only those portions of the vein and neighbouring rock which show the sulphides are selected, while quartz Character of veins.

Ontario-*Cont.*

free from such admixture is rejected as barren. By this means the ore taken to the mill is enriched fully 25 per cent.

Gatling vein.

'Although, as has been stated, these quartz or ore-bearing bodies are exceedingly irregular. two main lines of dislocation occur occupied by what are know as the Gatling and Tuttle veins respectively. These are approximately parallel to one another and have a direction of nearly north-and-south with a dip to the west in the case of the Gatling vein of 57°, and the Tuttle of 64°. The main work has been done on the Gatling vein at what is known as No. 1 or the Gatling shaft, and at the time of my visit (July 7) work had reached a depth of about 300 feet. The width of the vein is variable and at the wider portions "horses" of the associated rocks are included. At a depth of 200 feet the vein was lost after passing through fifty-seven feet of shattered and slickensided rock. It rapidly widened to two or three feet, this width being still maintained. Southward as ascertained by two drifts, the Gatling vein pinches out, but is replaced about 300 feet to the east by the Tuttle vein, which it overlaps. Northward it extends into the "Gatling Five Acre," as the property of another company is called. Two drifts have been run connecting the Tuttle and Gatling veins and work is being continued with promising results in both veins.

Smaller veins.

'Besides these comparatively large bodies of quartz, others which are described as feeders, enter them at sharp angles, producing at their junction a local enrichment of the main ore-body. The wider portions of the vein are relatively much poorer in gold than where these are more constricted. Two other shafts were likewise in operation on minor ore-bearing bodies.

Mass of diabase.

'An important area of intrusive rocks, somewhat similar in character to the Huckleberry Rocks, is exposed in the district immediately adjacent to the western and northern shores of Crow Lake in the western part of the township of Marmora and extending westward into the eastern part of Belmont. They appear to represent the truncated base of a very ancient volcanic centre, while certain hills which rise to the south-west, towards Preneveau P. O., are composed of a portion of the ancient lava flood. These hills rise in somewhat bold rounded outline from an otherwise comparatively level plain underlain by Palæozoic strata. They are composed of a dark-green often fine-grained diabase, in many places porphyritic, large phenocrysts of partially saussuritized labradorite being developed in a groundmass which often has macroscopically a distinct ophitic structure. In many places the rock is amygdaloidal, some of the vesicles, which are

Ontario–*Cont.*

Associated mineral deposits.

often arranged in rows, being empty, while others are filled with quartz and other secondary mineral. This mass is important, as being the parent, so to speak, of four noteworthy mines. The once famous Blairton iron mine is at the southern edge on the south side of Crow Lake, while the Belmont or Ledyard iron mine is on the north-west side. The Cordova (formerly the Carscallen) gold mine and the Ledyard gold mine are near the northern edge.

Character of the country-rocks.

'The main mass, or deep seated portion of this centre of volcanic activity, is for the most part a dark greenish-gray diorite. In many places the texture of the rock is exceedingly coarse and its main constituents are readily discernable without the assistance of a lense, while at other times it is exceedingly fine-grained and of a dark-greenish colour. Occasionally the rock shows foliation, though quite massive in structure, and in many cases this foliation is accentuated by the alternation of coarser and finer bands. The rock is evidently largely composed of a basic plagioclase (labradorite) and hornblende, and appears to be a gabbro-diorite with a broad ophitic structure allying it to the diabases. It is intimately associated with and cut by a red granite that ramifies through the more basic irruptive often in the most intricate manner. Pegmatite dykes were likewise noticed, and large, often exceedingly irregular, masses of allotriomorphic quartz. At times a certain indefinite vein-like arrangement may be noticed with what appears to be a tolerably well-defined hanging- and foot-wall, but both in their horizontal extension, and doubtless also in depth these veins exhibit extreme irregularity.

Occurrence of quartz.

Of course by following certain lines of disturbances and other signs learnt by experience by the miners, the ore-bearing body is frequently recovered at no great distance, and with an increase of experience in such work, many of the existing difficulties and disappointments may be overcome. The abundance of the quartz is a favourable factor in the problem, as in case of one body giving out, there is almost invariably another close at hand to work upon. In the vicinity of these masses of quartz, which for the most part fill residual spaces caused by the extensive deformation and fractures, the rocks have undergone considerable alteration, the resulting chloritization and seritization being the result of the combined action of chemical and dynamic forces. Considerable disturbance has in many instances accompanied the injection of the quartz, as horses or masses of the adjacent rock are caught up and altered by the containing silicious material. The quartz is of a very pale-grayish or whitish colour, and translucent. In many cases large masses seem entirely barren of any mineral whatever. At other times the quartz as well as the adjacent

Ontario-*Cont* wall-rock is highly impregnated with pyrite, ankerite, and chalcopyrite, and at the Cordova mine a selection is made of the material containing these sulphides, while the barren quartz and rocky matter are thrown on the dump as useless.

Belmont gold mine. 'The Belmont gold mine is situated on the east halves of lots 20 and 21 in the first concession of Belmont. It was formerly known as the Carscallen mine, and had been lying idle for some time until the Cordova Mining and Development Co. took hold of it in August of 1897. Extensive operations are now in progress, while the equipment seems very thorough and complete. Work is proceeding by means of six shafts, one (No. 6) of which is on lot 21 to the north of the road running towards Marmora, while the five others are to the south. No. 5 is a considerable distance to the south while Nos. 1, 2, 3 and 4 are close to the road and furnished with good shaft-houses. The ore-bearing bodies have in general an east-and-west trend and appear to belong to three distinct dislocations approximately parallel to one another with a dip to the south $< 60°$ to $70°$.

Ledyard gold mine. 'The Ledyard gold mine is situated on the east half of lot 19 in the first concession of Belmont township. The country-rock is much the same as at the Belmont gold mine, in fact the lots adjoin one another and the rocks can be traced with practical continuity from one location to the other. Quartz, very similar in appearance and composition to that at the Belmont and elsewhere throughout this mass of intrusive rock, may be seen in a large number of places on the property, the chief places where work has been done being known as shaft No. 1, the Burnt-knoll, the Hogs-back and the Nichol vein. The line of the Ontario, Belmont and Northern Railway runs through the property into the adjacent lot known as the Belmont Iron Mine. This railway, running through the village of Marmora, connects with the Central Ontario Railway near its junction with the Canadian Pacific Railway. Some work has been done on this mine, the main shaft having been sunk a distance of 100 feet, while large open-cuts have been made at the several places already mentioned. Suitable buildings have been erected, but at present the mine is lying idle in charge of Mr. W. C. Youman.

Old Feigle mine. 'The Old Feigle Mine near Malone station on the Central Ontario Railway was re-opened last April by Mr. O. R. Spragge, and a force of seven men was engaged in development work. The name of the mine has now been changed to The Sovereign. The main shaft is down a distance of 35 feet on quartz with a quartz-diorite as the country-rock.

'The Diamond mine situated on lot 14 in the tenth concession of Madoc, was not visited, but extensive operations were reported. Ontario-*Cont.*

'The Craig mine, comprising the south halves of lots 4 and 5 in the third concession of Tudor, may be mentioned as one of the places where a good deal of work has been done. It is on a sulphide-bearing quartz vein, which cuts fine-grained amphibolites.

'The Bannockburn mine is likewise closed down for want of capital to carry on operations.

'The increase in demand and price for iron has again directed attention to the large deposits known to exist in this district and to which attention has been drawn in previous reports. Iron ores.

'The Dufferin mine, near Malone, has been re-opened and has now been running pretty steadily for two years. Under contract with Mr. Lloyd Bulpit of Madoc, Messrs. Thomas Barnes & Co., of Hamilton, have been shipping about five car loads or 100 tons of ore per week to the smelter at Hamilton. Several very large open pits have been made to secure the ore which occurs in the form of large lenticular masses in crystalline limestone. The ore is a rather pure magnetite, although rough sorting is necessary to rid it of the sulphides which it is apt to contain in places. It is as a rule finely granular, although portions are coarsely crystalline and occasional cavities containing calcite exhibit rather perfect octahedral forms. Dufferin mine.

'The Wallbridge hematite mine near Eldorado is being steadily worked, the ore being shipped to the Hamilton smelter. Wallbridge mine.

'At the Belmont iron mine a few men were engaged stripping the covering of soil to ascertain the quantity and quality of the ore beneath. The mineral seems to occur as a differentiation product of the massive basic irruptive with which it is inclosed. The ore is a magnetite seemingly very free from sulphides. Trial shipments have been made of five car-loads each to the Hamilton and Deseronto smelters, while 165 barrels have been sent to Glasgow, Scotland. Belmont mine.

'The Coe Hill also made a trial shipment of some of the ore which has been lying exposed for years on the dumps, while inquiries are being made looking to the opening up of the once famous Blairton iron mines. Coe Hill mine.

'Mining for mica has been carried on in a desultory way for years, the difficulties being either a scarcity of the mineral or too large a percentage of iron to make it marketable at remunerative prices. Mica mining.

'Messrs. Hughes and Colter, of Bancroft, have opened up a deposit of what seems to be a biotite on lot 30, in concession XIII of Cardiff. Many of the crystals are very large and free from checks or inclusions,

Ontario—*Cont.* but they are very dark in colour. The mica occurs in a vein with crystals of albite, orthoclase and pyroxene in a gangue of calcite cutting the fine-grained reddish gneisses. Mr. Dickson, of Cardiff, has also some rather promising showings of mica, some of which were being developed under option during last summer.

Lead mines. 'Several important finds of galena have also been made in this district and a great deal of work has been done in their development, some ore having been shipped. The two most important locations are known as the Hollandia and Katherine mines. The former has been in operation for several years and about 400 tons of cobbed ore has been taken out and shipped to Belgium. The mine itself is situated a short distance north-east of Bannockburn. The galena occurs rather unevenly disseminated in a gangue composed chiefly of calcite, forming an irregular vein along a line of dislocation running in a direction of S. 54° E., cutting the highly inclined amphibolites of which the strike is N. 45° E. From forty-seven to fifty men were put to work, with twelve cobbers, but the mine has now closed down.

Katherine lead. 'The Katherine lead, zinc and silver mine situated in the eastern part of Lake a few miles west of Millbridge was opened last spring under the direction of Mr. Freeman Daniels of Ottawa. Considerable ore has already been secured and is lying on the dumps ready for shipment. The vein and associated rocks are very similar to those occurring at the Hollandia, but a considerable amount of blende is present in addition to the galena.

Corundum deposits. 'Further work was also accomplished in tracing out the relations and distribution of the syenites with which the corundum deposits are associated. In view of the expected early publication of the final report it is unnecessary here to go into many details.

'The Nepheline syenites, with associated red syenites and granites, are now believed to constitute a fairly well-defined belt of varying width that runs with more or less continuity across the Haliburton map-sheet from Glamorgan on the south-east to Brudenell near the north-east corner. Starting from Glamorgan, this band runs through Methuen curving around through the northern parts of Cardiff and Faraday, passes through Bancroft and the central part of the township of Dungannon as far as the York River. Thence north-eastward it follows very closely the depression occupied by the York River through Dungannon, Monteagle and Carlow townships. With perhaps some important breaks it crosses Raglan into Brudenell and thence passes eastward towards Clear Lake and the Opeongo road. While it is believed that many breaks occur to interrupt the continuity of this

band, but the more work that is done tends to make these interruptions less important, so that for all practical purposes it is perhaps expedient to describe and map the occurrence as one unbroken band. Ontario-*Cont.*

'During last summer Mr. T. H. Hodgson of Kingston was engaged prospecting for corundum along the valley of the York River for Messrs. Shenstone and Craig, who have since signed a lease which calls for the energetic development of a new industry in connection with this mineral. Incidentally Mr. Hodgson has done very valuable work in tracing out and correlating the various belts of nepheline-syenite, the information he has thus gained being placed at our disposal through his courtesy and kindness.

'Some of the discoveries made during last summer would seem to lend support to the view that the gem varieties, especially sapphire, may yet be found, in fact some crystals found by Mr. Hodgson and the writer very closely approach this gem in colour and transparency. Prospectors might direct their attention to a careful search along the tract of country in the valley of the York River from the crossing of the Mississippi road in Dungannon as far as the township of Carlow. Special attention should be paid to the crystalline limestones, as despite opposing views which may be held concerning the origin of these, there is a remarkable similarity in their association with the corundum to that occurring in Burma.

ONTARIO.

(With adjacent parts of Quebec.)

The winter of 1888-89 was spent by Dr. R. W. Ells, in the compilation of the map-sheets along the upper Ottawa and in writing a report on the geology pertaining to map-sheet No. 119. Work by Dr. R. W. Ells.

The work of the summer of 1899 was devoted principally to completing the surveys in connection with map-sheets, Nos. 119, 120, 122 and 123, which have been in course of compilation for several years. Special attention was also given to the study of the formations around Ottawa city, in connection with the publication of the special map of this district on the scale of one mile to the inch, the compilation of which is well advanced. Dr. Ells reports as follows :—

'Surveys were carried on continuously during the season, mostly in the area between the Ottawa and St. Lawrence rivers on map-sheet, No. 120, which was commenced some years ago by the late Mr. N. J. Giroux, but which he unfortunately was unable to complete. This Surveys made during the summer.

Ontario *Cont.* work was largely entrusted to my two assistants Mr. R. Hugh Ells, B. A., and Mr. Howells Frechette by whom the necessary surveys for its final completion were conducted. This sheet is an important one, since in this area are found all the Palæozoic formations from the base of the Potsdam to the Medina. Large portions of the district are, however, occupied by deposits of clay and sand, and there are several peat-bogs of large size and possible great value for the manufacture of compressed peat and moss-litter. Ridges of large size, often chiefly composed of boulders of crystalline rocks in which are great prominent masses of labradorite, are frequent. In this district also, some fine farming lands are situated.

Work on upper Ottawa.

'A number of surveys were also made during the summer along the upper Ottawa in the direction of Chalk River in the townships of Petewawa and Buchanan, and in that part of Quebec above Allumette Island; also on Calumet Island and in the township of Litchfield. In association with Mr. James White, surveys were also made in Templeton township, and in Gloucester and Nepean, to complete the details of the Ottawa map, as also in the township of Hull where the geological structure is somewhat complicated.

Time spent with Prof. Osann.

'In the latter half of August, two weeks were spent with Professor Osann, of Mülhausen, in the study of certain portions of the crystalline rocks north of the Ottawa, between Ottawa city and the town of Lachute, in order to obtain materials for a report on certain eruptive masses, that occur more especially in connection with the economic minerals of that area, such as mica, graphite and apatite. The results of this work it is expected will be great value as affording light on the origin and mode of occurrence of these important minerals.

Progress of work on map-sheets.

'The work on the four map-sheets named above, is now sufficiently advanced to render the compilation of the several maps possible. Much difficulty has been experienced in this respect from the fact that many of the old township plans, the Crown Lands Department, are so incomplete as to be in some cases almost worthless for this purpose, and this has necessitated the making of a certain number of special surveys of railway and other lines with the object of furnishing the necessary framework for their construction.

'In the area included in map-sheet No. 119, great difficulty has been found in defining the boundaries of the several Palæozoic formations. Owing to the extensive deposits of clays and sands, rock-exposures are in many cases widely separated; and while advantage has been taken, as far as possible, of wells and borings, the thickness of the recent materials is often so great that in these the underlying rock has not

been reached. In all such cases the tracing of formation-lines has of necessity been effected by connecting the different and widely separated outcrops along their strikes. Valuable information has, however, been obtained from certain wells which have penetrated to underlying strata and from various quarries where the overlying soil has been removed. Ontario-*Cont.*

'In other places, the distribution of the drift, which has been uniformly from the north and north-west, has afforded some information. While therefore, in a country so widely covered with recent material as that between the St. Lawrence and the Ottawa rivers, it has not been possible to accurately define all the boundaries, it is believed that this has been done with a fair amount of success.

'The geological structure about Ottawa and for some miles to the south and east is somewhat complicated. Numerous faults occur, which, while generally rather local, have rendered the mapping difficult. Some of these separate the Calciferous from the Utica, others affect the Trenton and Black River formations, or separate the Trenton from the Calciferous. The tracing of some of these faults has been carried out as well as the overlying surface-deposits permit. To the south of this faulted area near Ottawa, the formations come in regularly, and it has been conclusively established that in the Ottawa and St. Lawrence area, in the counties of Prescott, Grenville, Dundas, Stormont, Russell and Glengarry, these formations occur in the form of a well-defined basin. In this area, although several small faults and low undulations are seen, the formations are fairly regular in their distribution. The highest beds yet recognized are the red shales referred to the Medina, and surrounding this area the grey fossiliferous sandstones and shales of the Lorraine were recognized at a number of points in the townships of Russell, Gloucester and Cumberland. Geology of vicinity of Ottawa.

'The Calciferous formation which first appears on the Rideau River near the Black Rapids rocks, about four miles south of Hogsback, extends without interruption across to the St. Lawrence at Prescott and down the north side of that river for some miles, being seen in the canal excavations at Iroquois. Several well-defined faults are seen at Hogsback, between the Chazy and the Black River formations, which extend for half a mile or more north of that point, following the course of the river. The measures are here broken across by another line of fault between the Trenton and the Black River that extends southeasterly from the north side of the Ottawa, in the village of Tetreauville, the beds of the latter formation being in places inclined at an angle of seventy-five degrees. To the south of Hogsback other faults Calciferous formation.

Ontario-*Cont.*

occur, notably at the corner of the roads on lot I, ranges II and III, Gloucester. This faulted area involves the Chazy, Black River and Utica formations. To the south-east a heavy fault, which is probably connected with this disturbance is seen on lot 10, range VI. of the same township, where the tilted beds of the Calciferous are in contact with the Utica shales. To the south-east of this the surface becomes covered with heavy masses of sand and clay, and this dislocation is traced with difficulty, but it presumably extends through the north-east corner of Osgoode into the township of Russell, the regular succession of formations from the Calciferous upward appearing along the south side.

Faults south of Ottawa.

'To the south of Hogsback another fault is seen on lot 3, range II, of the same township, between the Chazy and Black River limestones, but before reaching the Black Rapids the succession of the Chazy shales on the Calciferous is regular.

Trenton basin.

'A long tongue of the Calciferous extends eastward from the main mass on the Rideau River into the northern part of the county of Dundas, continuing along the north line of the county to a point north of the village of Chesterville. This is conformably overlain on both sides by the shales of the base of the Chazy, which, on the north side of the axis, pass upward regularly through Black River, Trenton, Utica and Lorraine. On the south side, the highest beds seen belong to the Trenton formation, and these are well exposed about South Finch, the northern part of the Trenton basin in this direction being near the village of Crysler. The centre of the northern basin is near the middle of the township of Russell close to its eastern border, while the centre of the southern basin is found, apparently, near the middle portion of the townships of Kenyon and Roxborough. The exposures of the Black River formation, seen along the line of the Ottawa and Cornwall Railway, between Cambridge and Embrun, were useful in working out the structure of this part of the basin.

Formations along the St. Lawrence River.

'Along the St. Lawrence River, the construction of the new sections of the canals at Cardinal, Iroquois and at other points have furnished materials for fixing boundaries hitherto lacking, and in this way the approximate divisions between the Calciferous, Chazy and Black River formations have been obtained. Thus the beds of the former were noted in the bottom of the excavation at Cardinal and at Iroquois, where the clay covering is very heavy and where no data could be obtained at the surface. The town of Iroquois is apparently nearly on the eastern limit of the Calciferous on this shore of the river, since at Sheik Island the next recognized outcrop is of the dolomitic limestones at the base of the Chazy formation. Two miles north of this the Mille

Roches quarries are in Black River limestones. These quarries are extensively worked for stone for canal construction, and blocks of very large size and of excellent quality are here obtained, one solid layer having a thickness of nearly ten feet. A short distance north of this the limestones of the Trenton formation come in. Ontario—*Cont.* Mille Roches quarries.

'A re-examination of the quarries at Glen Robertson and at St. Justin was made and the rocks there found to belong to the Black River formation, though from a small collection of fossils made several years ago their age was then assumed to be Trenton. The railway at Glen Robertson is presumably near the line between the Trenton and the Black River, the beds of the former showing to the south and also to the west at Alexandria. The characteristic fossils of the Black River are abundant at the Glen Robertson quarries. Another Black River quarry is seen on the River à la Graisse in the south-eastern portion of Hawkesbury east, where they have a dip to the south-west at an angle of about ten degrees. They are here separated by a heavy fault from the Potsdam sandstone about two miles west of the village of Ste. Anne de Prescott. The latter formation extends thence north-east to Rigaud village and the line of fault continues from its contact noted above with the Black River to the foot of Rigaud Mountain, with which it may be connected. Glen Robertson quarries. Rigaud fault.

'This fault is an important one and has affected the continuity of the several formations over a considerable distance. The course of the fault is nearly north-west and the strata of the Trenton, Black River and Chazy, have been displaced along its course, for a distance of nearly nine miles.

'To the south of the Potsdam area, near Ste. Anne de Prescott, the Calciferous formation comes in in regular sequence, succeeded towards Glen Robertson by the Chazy and the Black River of the latter place already referred to.

'The distance east and west between the two great Calciferous outcrops, viz., that from Rigaud westward and that from the Rideau River eastward, north of Chesterville, is about thirty-six miles. The breadth of the Trenton basin between these points is about twenty miles, and this is overlain near the village of Maxville by Utica shale, which is regarded as another outlier of the great Utica area that extends easterly from the city of Ottawa nearly to the Vankleek Hill and which, in the townships of Cumberland and Russell, has a breadth of not far from eight miles. Utica shale outlier at Maxville.

'Throughout the greater part of this large area the formations lie in a nearly horizontal attitude. Around the margins of the Calciferous Anticlines.

Ontario-*Cont.* axes there is a divergent dip of five to six degrees, so that the basin shape is well-defined. Several low anticlines are seen in the Calciferous, one of which was noted in the northern part of the township of Osgoode, about lot 15, range V., where the beds have reverse dips, to the north and south, of five degrees. A similar low anticline with a curving outline was observed to extend from the vicinity of Merrickville on the Rideau for several miles past Oxford Mills, the reverse dips being at the same angles. This anticline was traced for about ten miles till the strata became entirely concealed.

Embrun quarry in Black River limestone.

'High dips are, however, rarely seen and then only near lines of fault throughout the Palæozoic basin. The steep dips in the vicinity of Ottawa have been referred to, where they sometimes reach as high as seventy-five degrees. On the line of the Ottawa and Cornwall Railway, about half a mile south of Embrun station, in a quarry of Black River limestone holding an abundance of fossils, the angle of dip is ten degrees to the north-east, but this formation is overlain by the Trenton limestone a short distance east of Embrun village to the north-east of this point.

Quarries south of Ottawa.

'Few mineral substances are found in the area to the south of the Ottawa in economic quantity. Quarries are, however, numerous and are situated generally in the limestones of the Black River formation which has been found to yield the best quality of stone for building purposes. Others have, however, been worked in the limestones of the Calciferous, Chazy and Trenton, as also in the heavier sandy beds at the base of the Chazy, which are especially well suited for foundation work. There is a large quarry of this rock about two miles east of the village of South Mountain on lot 2, range I., Mountain Township. The most important quarries in the Chazy limestones are near the village of Winchester, on the road thence to North Williamsburgh. The rock here is used both for lime-burning and for building stone. On lot 7, range I., Winchester, there is an excellent quarry of flaggy limestone in layers of about six inches thick, from which flags of any required size can be obtained. This is owned by Mr. William Bolton. A similar flaggy limestone is seen in a quarry on lot 39, range VIII., Williamsburgh. These are near the base of the Chazy limestones, while most of the Winchester quarries are in the grayish somewhat nodular limestones belonging to the upper portion of that formation.

Quarries near Winchester.

Quarries near the St. Lawrence.

'The quarries in the Calciferous formation yield stone principally for local use. The stone is largely dolomitic, but the quarries are not extensive. Along the St. Lawrence east of Prescott, where this formation is extensive, several large quarries are however, found, and are

worked somewhat extensively. The principal quarries in the Black River limestone at Mille Roches, Glen Robertson, &c., have already been referred to. Ontario-*Cont.*

'Large and important deposits of peat are found at a number of points. Most of these are near railway lines, and could be easily operated for the manufacture of moss-litter or compressed peat-fuel. The Mer Bleue bog to the south of Ottawa, lying between the lines of the Canada Atlantic and Canadian Pacific railways, with an extent of several thousand acres, has already been referred to in a former report, and is one of the most important. Among other deposits of value may be mentioned the bog at Newington, through which the Ottawa and Cornwall Railway passes, which is said to be of excellent quality and of large extent. The Moorewood bog, situated about three miles north of Chesterville, is reported to have an area of about 1,000 acres and a depth of twenty feet in places, and can be readily drained. Another bog, with an area of about 400 acres and a reported depth of twenty feet, is found on the town-line between Oxford and Wolford, about three miles east of Merrickville on the Rideau River. Other bogs, some of large size, are found in the township of Osgoode, but these have apparently not yet been proved, though one of them at least is crossed by the railway from Ottawa to Prescott. The importance of these bogs as a possible source of supply of fuel is now being realized and inquiries as to their location are frequent. The large bog near Caledonia Springs has also a good location near the line of the Canadian Pacific Railway, which in fact crosses the western end, but no details as to the thickness of the deposit are to hand. Peat bogs.

'Mineral springs are quite common in this area. The character of the water varies, some of the springs belonging to the sulphur class, while others are saline and gaseous. Those in the more immediate vicinity of Ottawa as at Eastman, and at Borthwick's, and the Victoria springs, near the Montreal road, are already well known locally. The celebrated springs at Caledonia have long been a favourite place of resort. Other springs south of Winchester are very similar in character. The most of those in the central basin appear to derive their water from the Chazy. The Caledonia is found on the Trenton limestone, while those at Eastman are apparently underlain by the Utica or Lorraine shales. At this place there is a heavy body of clay, generally not less than forty feet in depth. Mineral springs.

'The work of the season began on May 4, and ended on October 4.'

Quebec.

Work by Prof. J. A. Dresser.

On the work done by him in connection with the special examination of Shefford Mountain, Professor J. A. Dresser sends the following preliminary note :—

Shefford Mountain.

'The examination of Shefford Mountain is now so far advanced that a detailed map and description of it are in course of preparation. It was stated in the Summary Report for the year 1898, that this is a mass of igneous rock about nine square miles in extent with an elevation of rather more than 1,000 feet above the surrounding country ; the rocks being intrusive through strata of Cambrian and Cambro-Silurian age ; that the intrusion is probably of the nature of a laccolite, uncovered by extensive denudation ; and that the igneous rocks are of three, or possibly four, different ages of intrusion.

Areas of different igneous rocks.

'The work of the past summer, continued after a preliminary microscopic examination of the specimens previously collected, confirms these conclusions in their essential features and makes it possible to define the rocks with much greater accuracy and precision. The extent of each of the different classes of igneous rocks has been traced out as carefully as the nature of the locality and the means available permit. These rocks, exclusive of the later dykes, are now found to belong to three periods of intrusion only. The first in order of age is that which forms the extreme eastern part of the mountain, from McCutcheon corner to Morriseau's quarry, and also its most westerly portion about Ccupland Lake. It is generally of a rather coarse granitic structure, but varies considerably in different parts. The chief mineral constituents are felspar (largely plagioclase), hornblende, augite and biotite, while apatite, magnetite and sphene are noticeable amongst the accessories. It may be generally classed as an augite-diorite.

First period of intrusion.

'An interesting section through the zone of contact with the sedimentary rocks was exposed for a time in the building of an aqueduct leading to the town of Granby. Here the texture of the rock is variable, hornblende becomes more abundant and very small amounts of nepheline and sodalite appear. Here, as in most parts of the original contact-zone at least, this rock passes into the rarer type essexite.

Second period.

'The second of these rocks is a highly felspathic syenite, the greater part of the area occupied by it consisting almost entirely of the peculiar orthoclase-albite intergrowth, microperthite. The other constituents, augite, hornblende or biotite, seldom constitute more than a very

small proportion of the rock, especially in the central part of the mass. Quebec *Cont.*
But near the edges there is a considerable increase in the amount of the darker minerals, the character of the felspar is changed and microscopical amounts of nepheline appear, as well as larger sphenes.

'This rock forms the central part of the mountain, breaking through the earlier igneous rock, and both on the northern and southern sides has been injected along the previous line of contact of that rock and the sedimentary slates. A marginal modification of it is seen in the rock of Dounan's quarry.

'The rock of the third age of intrusion is holocrystalline, but gen- Third period.
erally porphyritic in structure. Along its margin and in the numerous dykes given off from it, the groundmass is finely crystalline, chiefly of felspar and the porphyritic crystals, or phenocrysts, are prominent. But near the centre of the mass the texture of the rock becomes much coarser and the porphyritic aspect is less conspicuous. Hornblende is the most abundant bisilicate, although augite is occasionally present. A little sodalite can be seen by the unaided eye.

'This rock is generally inclosed by the syenite previously described, but for a distance to the south-east of Coupland Lake, it appears to have been intruded along the former line of contact between the two earlier igneous rocks. It forms most of the higher part of the mountain above Notts corner.

'A very brief examination of Brome mountain was also made. Brome mountain.
This mountain which is only four miles distant from Shefford mountain at the nearest point, occupies about twenty square miles. The exposures along most of the principal roads, that cross the mountain in different directions were visited, and specimens were obtained from other places, quarries, &c., that were not seen. Only one type of igneous rock was found, and this presented little, if any, variation in all the specimens seen. It is syenite which apparently differs from that of the second intrusion at Shefford, only in containing a considerable amount of nepheline.'

Hudson Bay.

Mr. A. P. Low, during the sumer of 1898, explored the east coast of Work by Mr. A. P. Low.
Hudson Bay from Cape Wolstenholme southward to Great Whale River, where he remained the following winter. An account of his exploration to that place was given in the last Summary Report. In continuation, Mr. Low writes as follows :—

'During the months of December and January, the days were too Winter at Great Whale River.
short and cold for extended field-work, and operations were confined to

Hudson Bay —*Cont.*

short snowshoe tramps and trips with dog-teams in the vicinity of the Hudson's Bay post at Great Whale River, and to interviews with northern Eskimos, who, at that time, paid their annual visit to the post. A large amount of information was obtained from these people concerning the northern interior and the Belcher and other islands lying off the coast, as well as sketch-maps, which will in a manner fill the blank space on the maps of the north-western portion of the Labrador peninsula.

Journey northward in February and March.

'Early in February preparations for the spring work were begun, and it was decided that Mr. Young, my assistant, should make a micrometer survey of the coast between Richmond Gulf and Fort George at the mouth of Big River, so as to fix the position of Cape Jones. For this work he was provided with two Eskimo guides and a team of nine dogs, while J. Schupe accompanied him as assistant. Having started Mr. Young, I next prepared for my trip northward into the barren grounds, and left on the 23rd with two Eskimo guides and a team of twelve dogs, at the same time Lantz and Ford were sent inland with 800 lbs. of provisions, with instructions to store them at the second forks of Great Whale River, where they would be available on our trip up the river at a later date. We travelled slowly northward over very rough ice piled along the coast, and took three days to reach Little Whale River, when, by the advice of the guides we visited a band of Eskimos living on the ice about ten miles off the land, where they were employed killing seals in a great crack that extended far seaward. The band consisted of about sixty persons living in about a dozen houses made from blocks of the lightly packed snow lodged among the upturned ice along the crack. We borrowed a sleigh and seven dogs from them and continued our journey at a much increased rate.

Tree limit on the coast.

'On our way northward we met many Eskimos travelling to the Hudson's Bay post. They usually travel in small parties of two or three families, each with an overloaded dog-sled; they all greeted us cheerfully and asked for the customary present of tobacco. The northern tree-limit on the coast is just north of Richmond Gulf, beyond which we had to depend for fire on a precarious supply of drift-wood dug from beneath the snow, so that several nights our cotton tent was rather cold and we were obliged to cover up tightly in sleeping bags to keep warm.

Turn inland.

'On March 2, we left the coast, about ten miles north of the mouth of Nastapoka River, and quickly rising about 700 feet from the sea, passed eastward through a number of small lakes surrounded by bare

rocky hills that rose from 300 feet to 600 feet above the lakes, and were almost totally devoid of vegetation. This barren region continued about thirty miles inland from the coast, when the hills become less rugged and the valleys contain some soil on which clumps of spruce and larch grow. At first the trees are not a foot high, but soon increase to eight or ten feet in height, while the trunks are several inches in diameter, and afford a supply of fire-wood. Hudson Bay —*Cont.*

'Ten miles further on, we crossed the water-shed dividing the rivers of Hudson Bay from those flowing eastward into Ungava Bay, and descended slightly to Tasiagaluk or Eskimo Seal Lake. We followed the lake for about forty miles or about one-third of its length, but, being unfortunate in not finding the barren-ground caribou, although the snow on the lake was everywhere beaten with their tracks, we were forced to turn back for lack of food for the dogs. The Eskimos describe the lake as being over 100 miles long with several long narrow bays all having, like the main body, an east-and-west trend. In its widest part it does not exceed fifteen miles across, and towards its eastern end it gradually narrows into the Leaf River, which discharges its water into Ungava Bay. It is reported that there are no direct falls on the river, the natives being able to ascend it to the lake with their umiaks or large skin boats. The small shrub spruce and larch grow along the river-banks to within twenty-five miles of its mouth. Eskimo Seal Lake. Leaf River.

'The country surrounding the lake and along the river is comparatively flat, with low ridges of rocky hills rising from 50 feet to 200 feet above the general level. With the exception of a few small areas of dark basic rock, near the point where we turned back, only red granite was observed between the coast and Tasiagaluk. A track-survey was made of the route followed with considerable difficulty, as the thermometer ranged between–20° and–45° F. We were joined by Mr. Young on March 11 at Richmond Gulf, where he had just completed the survey of the coast, and we returned together reaching Great Whale River on the 13th. The men sent inland with provisions did not return until the 19th and reported great hardships from intense cold and deep snow. Country and rocks.

'We did not start up Great Whale River until April 3, owing to the deep, soft snow. The party consisted of myself, Young and three white men, without guides, and each hauled a sled loaded with about 300 lbs. of outfit and provisions. The work was very difficult and slow for the first week, owing to the deep granulated snow into which the sleds continually sank to the cross-bars. After the 12th the weather became soft with frequent rains, which caused much delay, and on the 30th we were obliged to stop work owing to the breaking up of the ice, Journey up Great Whale River.

Hudson Bay —*Cont.*

which forced us to leave the river and to travel overland to the coast; which we reached near the north end of Manitounuk Sound, returning to Great Whale River post, on the 5th of May.

Course of the river.

'The result of this trip was a survey of the north branch of the river to within a few miles of a large lake, that discharges by this river and also by the Little Whale River. The distance from the mouth of the river to where we left it is nearly 100 miles, which, together with fifteen miles on the Abchigamich Branch, represents the total survey made. The river, for about thirty miles from its mouth flows from the eastward, but then changes its direction, and from the Abchigamich Branch flows southward thirty-five miles. The Abchigamich comes from the north-east, while the valley of the main branch bends to the south-west from the forks, gradually turns west, and then northward parallel to, and about twenty miles inland from the coast.

Rocks.

'The region throughout is formed of rugged granite hills with the river flowing between them in a usually narrow valley. The river is frequently broken by falls and rapids all open when we saw them, and exceedingly difficult to pass with loaded sleds along the narrow margin of snow and ice adhering to the steep rocky walls of the valley. The country is generally wooded with small black spruce and larch.

Unseasonable weather.

'The river was clear of ice from the post to its mouth on May 12, this being the earliest break-up on record in the journals of the post dating back to 1860. The mild weather of the early part of the month was followed by cold stormy weather lasting into June, which greatly retarded our work of preparing the yacht for the summer's use. On June 1, we moved aboard the yacht ready to sail as soon as the ice left the coast. We sailed on the 5th, but had to return owing to an ice-blockade in the Manitounuk Sound, but the next day passed through, as the ice was moving out, and so reached the north end of the sound. The following day we proceeded northward, passing through much ice, and just reached the mouth of Richmond Gulf when the wind changed, jamming the ice tightly on to the coast, and so it remained for the next two weeks. Luckily Richmond Gulf was free from ice, except a few large cakes about its outlet, and we were able to make a survey of that large salt water lake and also to thoroughly examine the rocks about it.

Richmond Gulf.

'Richmond Gulf is a triangular body of salt water, widest at its southern end, where it measures eighteen miles from east to west, while its greatest length is twenty-three miles from north to south. It is separated on the west side from Hudson Bay by a narrow ridge of stratified rocks capped by trap. Facing the gulf, these rocks rise

in cliffs from 500 to 1,500 above the water. The stratified rocks and the traps also form high cliffs along the other shores and on the islands of the gulf, except where arms of intrusive granite come out in a few places along the southern and eastern shores. A deep narrow break in the ridge, near the south-west angle of the gulf affords a connection between the gulf and sea, and through it the water rushes with great velocity with the rise and fall of the tide. The entrance is dangerous for small craft, and is rendered more so from the violent squalls that break down over the cliffs whenever the wind is from the sea. Small trees of black and white spruce and larch grow about the margin of the gulf, and on its east side rise nearly to the summit of the hills, in marked contrast to the barren coast of Hudson Bay outside the gulf. A few clumps of balsam poplar were seen on the islands, proving this species to grow almost to the limit of the spruce. Hudson Bay —*Cont.*

'The rocks about Richmond Gulf, with the exception of large masses of intrusive granite on the south and east sides, are stratified sediments. Everywhere dark, red and green sandstones, with interbedded felsitic shales, are seen overlying a coarse, light-coloured grit or arkose, containing pebbles and fragments of felspar and quartz. These beds are usually greatly disturbed, and are associated with much dark-green trap and diabase, both in sheets parallel to the bedding-planes, and in large, more or less vertical dykes, cutting the bedded rocks. The dark sandstones and shales appear to represent the lower members of the so-called Cambrian of Labrador, and towards their top are probably equivalent to the iron-bearing rocks of the Nastapoka Islands, which lie along the coast outside Richmond Gulf. Although these shales and sandstones are very ferruginous, they were not found to be sufficiently rich in iron to make them commercially valuable. Rocks of shores. Cambrian series.

'The lower part of the high ridge separating the gulf from the sea, is composed of this series, and unconformably upon them rests a series of cherts, black shales and siliceous dolomitic limestone, capped with a great thickness of amygdaloidal trap. This series is thickest to the south, and thins out towards the north end of the gulf, where only about 50 feet of siliceous limestone intervenes between the dark sandstones and the capping of trap. The limestones immediately below the trap form a ledge which may be followed from the north end of Manitounuk Sound to beyond the head of Richmond Gulf, a distance of over seventy-five miles. The limestone contains many old cavities, now partly filled with quartz and usually containing much pyrite, and in a number of places galena has been found associated with the Galena.

Hudson Bay —*Cont.*

minerals. These lumps of galena vary from one inch to fifteen inches in diameter, and may be found in some places, in sufficient quantity to be profitably worked. Such a locality has been reported to have been found last summer between the Little Whale and Second rivers, but I did not see it, having left the locality previous to its discovery.

Return to Great Whale River.

'On June 22 the ice along the coast opened sufficiently to allow us to reach the mouth of Little Whale River, eight miles south of the outlet of Richmond Gulf. Here we were again ice-bound until July 1, when an off-shore wind opened a channel and enabled us to reach Great Whale River the following morning. The coast between the rivers is high and rocky, without any harbours, until Manitounuk Sound is reached, where good shelter is found behind the islands. From Boat Harbour, seven miles north of Great Whale River, to the head of the sound, the shore is occupied by a narrow strip of cherty limestone resting unconformably upon gneiss and granite. The Manitounuk Islands are made up of stratified cherts, dolomites and shales, capped with trap, and these also occur along the shore to the northward of the sound, as far as the head of Richmond Gulf. The coast and islands are partly wooded with clumps of black spruce that grow in the valleys and protected portions of the cliffs.

Impossible to reach outer islands.

'We were blocked by ice at Great Whale River until the 7th, when we sailed southward, and for the next three days were hazardously employed in working through the heavy ice until we reached Long Island, after which we had no trouble with ice. I had intended to visit the Belcher and other islands lying from 60 to 100 miles off the mainland, and forming a chain extending northward from opposite Great Whale River to the neighbourhood of Portland Promontory, but was advised not to attempt it by the Eskimos, on account of the ice. They predicted that the ice would not leave the bay until late in August, and would prove very dangerous to the yacht, owing to the strong tidal currents among the outer islands. Their predictions proved correct, for although the ice left the coast shortly after we proceeded south, the Hudson's Bay Company's ship *Lady Head*, reported that ice was encountered all the way down Hudson Bay to Bear Island in James Bay, where open water was reached on the 20th of August.

Great Whale River to Cape Jones.

'The distance from Great Whale River to Cape Jones at the entrance to James Bay is ninety miles, and the trend of the coast is about south-west. Southward of Great Whale River the land slowly decreases in elevation, and with the exception of the White Bear Hills, which reach the coast about thirty miles north of Cape Jones, the shore is comparatively low, and the country inland is covered with

rounded hills never more than 400 feet in elevation. For about forty miles from the river a narrow strip of cherty limestone appears to have been shoved up over the underlying gneisses. It is broken transversely in several places, and then affords fine boat-harbours. The remainder of the coast is occupied by gneisses and granites. Long Island and the smaller islands lying off this part of the coast are all formed of limestone, cherts and shale, similar to the rocks met with along the coast farther north. On Long Island these rocks are capped with trap, on the west side. The limestones and cherts are usually highly charged with pyrites, and on Long Island a vein of anthraxolite twelve inches wide was discovered by prospectors, who describe it as cutting the black shales. Hudson Bay —*Cont.*

'Leaving Cape Jones, we sailed down the east coast of James Bay, passing by crooked channels between numerous low islands, usually formed of coarse drift and shingle, with occasional groups of rocky islets, in which low ridges from the mainland were continued seaward. It would be very dangerous and almost impossible to follow the inner channels between the islands without a competent native pilot, as the channel is often very narrow and crooked, with submerged reefs and boulder ridges everywhere. We arrived at Fort George, at the mouth of Big River on July 13.

'The country between Cape Jones and Fort George is very flat, and the rocks are hidden beneath a mantle of drift, except where low ridges of granite hills rise a few feet above the level of the plain. Wastikyn, a peninsula a few miles north of Fort George, although only about 200 feet high, forms a prominent land-mark owing to the flatness of the surrounding country. The tree-line, along this part of the coast, extends almost to the ends of the points, leaving only the outer islands barren. The rocks met with are crystalline schists, and intermixed masses of granite. A number of large dykes of diabase cut all the rocks, and are evidently much newer than them. No deposits of minerals of economic value were found in this area. Cape Jones to Fort George.

'From Fort George we continued the survey southward along a coast very similar to that just described, but somewhat more broken and rocky, while a majority of the islands are also rocky. At Comb Hills, a low ridge of granite on the mainland terminates in a string of islands rising about 100 feet above the sea. At Paint Hills, a band of dark-green trap, about four miles wide, forms a chain of high islands running north-east and south-west, which extends about eight miles beyond the general line of the coast. This band also forms a small group of islands, called Solomon's Temples, which lies about six miles outside the Paint Islands. The highest summits on the Paint Coast south o Fort George. Paint Hills.

Hudson Bay —*Cont.*

Islands are about 300 feet above the sea-level. The trap forming these islands has been squeezed by the intrusion of syenite, which cuts it in large dykes and masses. The result of this squeezing is that in many places the trap has become foliated vertically, and now appears as well banded chloritic and hornblendic schists, while in other places it retains its massive character and often shows its original diabasic structure. These rocks usually contain much pyrite, especially where most schistose, and some of the bands appear to be sufficiently large and rich for working. In several of the syenite dykes cutting the trap,

Cape Hope.

plates of molybdenite were found. At Cape Hope, a similar band of trap forms one large and several small islands. This trap does not contain a large amount of pyrites, and no important economic masses were seen. The large island is about 300 feet high, and wooded to its summit.

Rupert House.

'The mouth of East Main River was reached on August 1, and we again changed pilots, sending the old one back to Fort George. We finished the survey at Rupert House, at the mouth of Rupert River, on the 19th, and then crossed the south end of James Bay to Moose Factory, where we arrived on the 21st.

'The coast between the East Main and Rupert rivers is very low, with wide mud-flats bare at low-tide. The water deepens very slowly, and it was dangerous to approach within a mile of the shore. In Rupert Bay the bottom has been filled up by the sand brought down by the Rupert and Nottaway rivers, and outside the narrow channel leading up the middle of the bay, not more than a fathom of water covers the wide flats at low-tide.

'Sherrick Mountain, situated on a peninsula at the mouth of Rupert Bay, is a very prominent landmark, rising as a granite hill about 400 feet above the water. The rocks met with along this portion of the coast are largely mica-gneisses, usually carrying much garnet, and probably including metamorphosed bedded rocks. They are frequently cut by dykes and masses of granite-gneiss, the irruption of which probably caused the alteration of the rocks cut by them.

Reach Moose Factory.

'At Moose Factory the yacht was stripped, and arrangements were made with the Hudson's Bay Company to have it hauled out and safely housed, so that it might be available for future use. The specimens collected were packed and shipped to Ottawa, via London in the *Lady Head*, and preparations were made for our canoe trip up the Moose River to the Canadian Pacific Railway. While the rest of the party were so engaged, Mr. Young made a micrometer survey from the factory to where a meridian line of the Ontario Government crossed

the river, some thirty miles up stream, in order to fix the longitude of Moose Factory. Hudson Bay —*Cont.*

'We left Moose Factory on the 29th in a large canoe, with four Indians to assist in poling up stream, and reached the railway at Missinaibie on September 12, having been delayed by the very low water in the river below the Long Portage. The following day we reached Ottawa where the party was disbanded.

'Among the results accomplished by the exploration may be mentioned a survey of the entire east coast of Hudson Bay, from Cape Wolstenholme, at the entrance of Hudson Strait, to Rupert River near the south end of James Bay; together with explorations inland on great Whale River, and to Eskimo Seal Lake. The numerous observations of the rocks show that crystalline schists, gneisses and granite occupy the greater part of the area examined; and that a band of unaltered rocks, belonging to the so-called Cambrian of Labrador, occupy most of the coast and islands from Portland Promontory to Cape Jones, while other areas of these rocks appear to have been inclosed and altered by later intrusions of granite. The unaltered rocks of the Nastapoka Islands contain large beds of iron ore very similar to the valuable ores of the south shore of Lake Superior. Results of the work. Iron ore.

'A pamphlet on the diamond fields of the great lakes, by Prof. W. H. Hobbs, was received at Moose Factory, too late for attention on Hudson Bay; but, in response to the suggestion of the Director, special observations were made while ascending Moose River on the drift and glacial striæ. These in my opinion confirm the view that the ice moved in a south-west direction from Hudson Bay, and therefore tend to show that the source of the diamond-bearing drift of Wisconsin and Michigan may be in the Hudson Bay region, or in the country to the east of the bay, where there are localities favourable to the occurrence of diamonds, notably the trap-capped carbonaceous shales of Long Island and the islands of Manitounuck Sound. Possible source of diamonds.

'The observations of glacial phenomena show that the peninsula of Labrador was completely covered with ice; that the centre of dispersion of the ice was first in the southern interior, and that it moved northward, finishing in the northern interior. The evidence of raised beaches and terraces show that the land has risen at least 700 feet since glacial times, but there is no evidence of an appreciable rise going on at present.

'Attention may be directed to the valuable fisheries of the east coast of Hudson Bay—Arctic salmon are plentiful in the northern waters as far south as Cape Jones, while trout and whitefish may be taken Fisheries

Hudson Bay —*Cont.*

abundantly along the entire coast. The existence of cod in Hudson Bay may prove of great value, but requires further investigation.

'A complete series of weather observations was kept throughout the entire trip and collections of plants, eggs, birds and other natural history specimens were made.'

NEW BRUNSWICK.

Work by Mr. R. Chalmers.

In the early part of the winter of 1898-99 some time was spent by Mr. Chalmers in revising proofs of his report on the surface geology and gold-bearing deposits of south-eastern Quebec. The remaining winter months were occupied chiefly in compiling the information obtained in the field during the previous summer and in laying it down on the map, No. 1, N. W., of the New Brunswick series—the Fredericton sheet.

Surface geology.

During the past summer, Mr. Chalmers continued the mapping of the surface geology of New Brunswick, as detailed by him below :—

'On the 30th of May I received your instructions to proceed again to New Brunswick and continue investigation on the surface geology of the area of sheet No. 2, S. W. (the Andover sheet) which lies immediately to the north of the Fredericton sheet, and if possible, complete the work on it at an early date. This has been accomplished, and the two sheets (No. 1, N. W. and No. 2, S.W.) will now be prepared for publication, accompanied by a report on the surface geology, forest growth, economic minerals, &c., of the district embraced therein.

'My assistants in the field were Mr. L. P. Silver, and, for some weeks in the autumn, Mr. W. J. Wilson of the Survey.

Special points investigated.

'The surface geology of the area embraced in the Andover sheet and adjacent districts is of a very interesting character. Some of the more important matters pertaining thereto, which have been investigated and studied during the season, are,—(1) the occurrence of alluvial gold in the eastern branches of the Tobique River, more especially the Right Hand Branch and the Serpentine ; (2) the physiography and elevation of the region ; (3) the character of the surface deposits and their relation to the soils and subsoils, and (4) the forest growth and the distribution of the various species of trees found growing within the area.

Deposits of St. John valley.

'In June and July a detailed examination of the deposits in the St. John valley and along its tributaries throughout the counties of Carleton and Victoria was made, partly from the roads and partly by

canoe. The glaciation was studied in every detail. No boulders referable to the Laurentian region to the north of the St. Lawrence, were observed within the area of the two map-sheets under examination. Heavy beds of boulder-clay occupy the valley of the St. John, but no interstratified materials were found in them, such as occur on the south side of the St. Lawrence valley in south-eastern Quebec, though in some places these beds attain a thickness of 50 to 100 feet. Great banks or moraines have been thrown down in the valley by the ice of the glacial period, partially filling it in places and forming drift-dams after the ice withdrew. These held up the river to a high level at the latter stage of the Pleistocene, and appear to have been the cause of the formation of the higher terraces now found along both slopes of the valley. New Brunswick—*Cont.*

'In a previous report these terraces have been described in some detail. The highest are immediately below Grand Falls; but in other places where constrictions or sharp bends occur in the valley, the drift-dams referred to, or glacial dams, which may have existed here at the close of the ice age, caused these terraces to be produced, at levels varying from 50 feet to 200 feet above the present river-bed. The succession in the terraces, like steps on a slope, indicates successive levels at which the river stood as it trenched its channel anew in the valley-drift since the glacial period. The terraces have all a slope down stream, and are seldom more than a half a mile to a mile long, generally much shorter. Terraces.

'During the month of August I took a few days to examine a supposed occurrence of iron, and a copper deposit on the north side of the Restigouche River near Campbellton, N.B. The site of the iron was at Little River, P.Q., on the Oatman farm, about eight miles from the Restigouche. The iron was found in a boring made for water to a depth of fifty-five feet. It was metallic iron, in small grains and pellets, and no other conclusion could be formed than that some iron implement or perhaps a part of the drill itself had dropped into the bore-hole. Examinations near Campbellton.

'The copper deposit is in the valley of the Scaumenac River, five or six miles from the mouth. The ore occurs as green carbonate and native copper in small stringers or grains, associated with calcite and some other minerals resembling zeolites. These occupy cracks and fissures in trap rocks, and appear to be irregularly distributed through them in a thin and scattered condition along a zone or band ten to fifteen feet wide, trending nearly east-and-west. This mineralized zone is near the contact of the trap rocks (felsites, diabases, &c.) with the Silurian limestones and slates. Occurrence of native copper.

New Brunswick—*Cont.*

'The zone crosses the river and apparently extends into the bank on both sides, but how far could not be determined. Some blasting had been done and a small quantity of ore had been taken away, but no work was going on at the time of my visit. The mode of occurrence of the copper as a secondary mineral formed in the fissures and joints of the intrusive rocks, apparently subsequent to their cooling and consolidation, would seem to indicate that it may be more than a mere local deposit in the river-valley. Whether it occurs in paying quantities, however, is not known, no development work having yet been attempted.

Gold in New Brunswick.

'*Alluvial Gold in New Brunswick.*—Reports concerning the occurrence of gold in the alluviums of the Serpentine River having been current in western New Brunswick for some time, it was considered advisable, when we were in that vicinity, to ascertain the facts. In the month of September, therefore, when the rivers were supposed to be lowest, I ascended the Right Hand Branch of the Tobique and the Serpentine with a log canoe and Mr. Manzer Giberson as guide, and explored the last-mentioned river, examining and washing the gravels in its bottom at a number of points. Fortunately Mr. Solomon Perley, of Woodstock, with two men, was there prospecting at the time, and to him I am indebted for much valuable information and assistance. He kindly pointed out to me a number of places where he had obtained alluvial gold, some of which we tested, but other new localities were also examined and a series of trials made which proved the existence of the precious metal in the alluviums, both below and above the Big Falls. Though no rich diggings were discovered, yet a fair showing of gold was found in several places.

Serpentine River.

'The Serpentine River flows in a westerly course into the Right Hand Branch, a tributary of the Tobique, the distance from where the latter joins the St. John River to where gold occurs being from eighty to eighty-five miles. Mountains 2,000 feet or more above the sea bound the Serpentine valley, which is itself in the gold-bearing district, from 1,000 to 1,100 feet in elevation. The country is rugged and broken and heavily wooded, and the river is extremely difficult to navigate with canoes, owing to waterfalls, rapids and the number of large boulders strewn along its bed.

Gold-bearing gravels.

'The character and mode of occurrence of the gold-bearing alluviums here are closely similar to those of other auriferous regions, notably the Chaudière valley, in the province of Quebec; and the succession of the beds, observed in several places, is as follows, in descending order:—(1) Coarse river-gravel, with boulders a foot in diameter and less; (2) fine gravel in deposits of greater or less thick-

ness, lying on bed-rock, sometimes oxidized and containing gold, and (3) rock, often with jagged, broken surfaces, which contains gold in the crevices. New Brunswick—*Cont.*

'In one place about two miles above the Big Falls, however, in what seemed to be an old channel of the river on the north side, the following series was noted in a pit opened by Mr. Perley :—(1) Fine river sand or loam, from one to two feet thick ; (2) sandy clay, with rusty, gravelly layers, about eighteen inches or two feet in thickness. Gold colours were sparingly met with in this. (3) Decomposed, talcose slates, fifteen inches, but the bottom was not reached. Colours of gold were also seen in this material.

'Alluvial gold has been found along the Serpentine from a point about two miles above its junction with the Right Hand Branch nearly as far up as the "dead-waters," which are about twelve miles from the mouth. But it seems to be more plentiful above the Big Falls than below. These falls are about eight miles and a-half up the Serpentine. Coarse gold has been found there in pieces weighing from two to six grains. At the time of my visit, however, but little prospecting had been carried on in the alluviums, except in the bed of the river and at a few places in the banks, and nearly all the washing had been done by the ordinary process of panning. Since then Mr. Perley has extended his examinations as far up as the "dead-waters" mentioned, and reports having found both coarse and fine gold, from three miles and a-half to four miles above the Big Falls. Places where gold is found

'Gold from the alluviums of Silver Brook, a small stream flowing into Nepisiguit River about three miles below Third Nepisiguit Lake, was also shown me ; and I have been informed that gold also occurs in the Little South Branch, the next tributary to the east. In the beds of these streams no exploratory work has been done, however, further than washing with a pan.

'Prof. H. Y. Hind, in 1865 *, reported alluvial gold also from Campbell River, Long Lake, the Little South-west Miramichi, and from the ridge between the two last-mentioned waters. It was likewise reported from Blue Mountain Brook.

'Taking all the facts regarding the occurrence of alluvial gold in this part of the province into consideration, it seems probable that the precious metal is to be found in the valleys of a number of the rivers and brooks flowing into the Right Hand Branch of the Tobique, and into the upper part of the Nepisiguit from the south. But the gold in these is extremely scattered, though, so far as can be ascer- General conclusions.

* A Preliminary Report on the Geology of New Brunswick, 1865, pp. 223-4.

New Brunswick—*Cont.*

tained, entirely of local origin. Nor has it yet been discovered in paying quantities. Judging from the specimens obtained, and from the character of the alluviums in which it occurs, however, it does not seem unreasonable to suppose that in some spots, at least, deposits may eventually be found that will be profitably wrought. More systematic exploration is required, not only in the valley of the Serpentine, but in the beds of the small tributaries flowing into it from the north, such exploration being directed more particularly to ascertaining the limits of the auriferous alluviums, and the localities where they contain most gold; also to further, testing the quartz veins at and above the Big Falls. Sluicing should likewise be more generally undertaken, especially at these falls and for two or three miles above them. The flats on either side of the river might also be more thoroughly examined, as in some places they evidently have old filled-in channels beneath, in which gold has probably been more plentifully distributed than in the present river bed.

Source of the gold.

'The original source of the gold has probably been in that portion of the wide band of pre-Cambrian rocks lying between Campbell River on the south and the Nepisiguit River on the north. These consist of schists and slates, often chloritic, or talcose with some quartzites. Intrusives frequently occur among them, and quartz veins are numerous. Gold has not yet been discovered in these quartz veins, but grains, or small nuggets, with quartz attached were met with in the alluviums. A small three-stamp mill has been erected in the Serpentine valley about six miles from the mouth of the river, and some work was done with it in testing the quartz veins in the vicinity; but so far as I could learn the results were uncertain.

'Black sand is abundant in the alluviums of some parts of the Serpentine and contains fine gold, though so far as examined, only in small quantities.

'The average gradient of the Serpentine River for the lower ten miles of its course is from 45 to 50 feet per mile, with two or three waterfalls in that distance. The quantity of water is amply sufficient for sluicing throughout the whole summer, and also for hydraulic work.

Other reported occurrences.

'Later in the autumn a visit was made to the Nashwaak and Cross Creek district, where gold was reported to have been discovered in quartz veins a year ago. In consequence of this report a large number of mining claims were located here in the winter of 1898-99. During the past summer some prospecting was done, but I could not learn that any gold had been found. At the time of my examination of the district I was fortunate in meeting with Mr. Chas. Welch, a

Klondike miner, and we carried out the exploration together. No gold was found by us at Cross Creek, either in the alluviums or in quartz; but in the Nashwaak valley, near Stanley village, a few very fine colours were panned out of the sands and gravels. If this gold belongs to the alluviums of the Nashwaak, it must have been transported a long distance, perhaps from the head of the river, or from the South-west Miramichi, it is so finely comminuted; but it is not unlikely that it may have been dropped by prospectors and others, who appear to have been washing and panning for gold in this valley at various times within the last thirty or forty years. New Brunswick—*Cont.*

'*Physiography and elevation.*—The physiography of that part of New Brunswick lying within the area of the two map-sheets referred to, presents great diversity. The surface, generally speaking, may be characterized as undulating, except on the divide between the St. John and the upper South-west Miramichi, where a rugged mountainous country exists, trenched by numerous rivers and brooks. The higher parts of this watershed attain altitudes of 1,200 or 1,500 feet above the sea. To the north-east, and beyond the limits of the Andover sheet, the region has much the same topographical features as above noted, and increases in height north-eastward as far as the head-waters of the Little South-west Miramichi, where we reach the most elevated portion of the province. Topographical features of country.

'The area referred to forms the south-west part of a wide irregular belt trending north-east and south-west, sometimes called the highlands of New Brunswick, the length of which is over a hundred miles and its width from thirty to forty-five miles. The south-west limit is within the area of the Andover sheet, and near the head of the South-west Miramichi, the north-east is at the sources of the Tête-a-gauche and Upsalquitch rivers. Transversely, it extends from the Little Tobique River and Nictor Lake to the North-west Miramichi waters. Though limited tracts contain arable land, most of it is unfit for settlement, and covered by forest. It is a country of lakes and rivers, with mountains, often bare and precipitous, that rise from 2,000 to 2,700 feet above the sea. Game and fish are plentiful, and it has already acquired a reputation as a sporting ground. It is also one of the principal sources of the rivers and of the water-power of the province. For a forest and game reserve and provincial park it can scarcely be equalled. Though protected to some extent by general provincial regulations, yet forest fires and unlawful destruction of game are not infrequent. A marked increase in the number of moose, deer, caribou and other wild animals has taken place there within the last decade, however, and salmon have likewise become much more Highlands of New Brunswick.

Protection of forest and game.

New Brunswick—*Cont.*

plentiful. This shows what can be done by protection. The time will come eventually when all the arable and timber lands of the province, which are accessible will be taken up and deforested. The large central area referred to can scarcely ever be utilized except for its timber, game and water-power. Some further restrictions besides those now in force respecting the fauna of this area, and the products of the forest, especially such as would tend to conserve the younger growth of trees, prevent the spread of forest fires, and check the indiscriminate killing of the wild animals and birds, would be of immense benefit to New Brunswick in the time to come.

Arable lands in Carleton and Victoria.

'*Agricultural character.*—The character of the soil in Carleton and Victoria counties is excellent, more especially in the St. John and Tobique valleys. On the west side of the St. John the whole country between Woodstock and Aroostook westward to the International boundary is thickly settled and under cultivation. On the east side the settlements extend back from the river twenty or twenty-five miles throughout the area of the Andover sheet. The tract of cultivable land referred to in the Tobique valley extends from the Red Rapids settlement to the Blue Mountains, and indeed, as far as Nictau. In the upper part of the valley, however, only the river-flats and terraces are cleared and under cultivation. A third area, which is well settled and contains a large number of good farms was observed along the Nashwaak River, Cross Creek, and crossing the country by the Taxus River to Boiestown on the South-west Miramichi. The district to the east of the Tobique valley, drained by the upper part of south-west Miramichi river, is unsettled and still in a wilderness condition, and is the scene of extensive lumbering operations.

Fertility of Silurian area.

'The Silurian area of north-western New Brunswick is occupied by some of the best land for agricultural purposes to be found in the province, except, perhaps, that resting on the Lower Carboniferous sediments. The excellent character of the soils in the St. John valley between Woodstock and St. Francis is mainly due to the fact that they are derived from the underlying Silurian rocks. The northern portion of the province is also occupied by soils resulting from the decomposition and waste of these Silurian limestones and slates. Large tracts of good land are found in this wide belt throughout. Its general character is shown by the farms in Madawaska and Victoria counties, and by those along the lower settled portions of the Restigouche valley. This large Silurian area is still mostly covered by the original forest growth. There are, however, many stony tracts in these uplands, the rocks being frequently traversed by dykes of intrusives, which, in their disintegration, have yielded boulders and coarse material to the soil. Notwith-

standing this mixture of stony *débris* with the calcareous soil, however, and the prevalence of early frosts in some localities, these uplands will offer an inviting and ample field for settlement when they are made accessible by roads. New Brunswick—*Cont.*

'Towards the close of field-work, Mr. Wilson made an examination of the district along a portion of the South-west Miramichi valley, still wooded, by following some of the lumber roads. He was thus enabled to sketch in the topography and forest-covered areas, and measure the elevation of the country by aneroid.

Professor L. W. Bailey was again employed in New Brunswick during the summer in making some special examinations of the so-called great slate belt of the province, also, for a part of the time, in obtaining specimens of New Brunswick minerals for exhibition at Paris. His report is as follows :— Work by Prof. L. W. Bailey.

'In accordance with your instructions, received in May last, the early portion of the summer was mainly directed to obtaining specimens of economic minerals to form a part of the Canadian exhibit at the Paris Exposition of 1900. With this object in view, in addition to extensive correspondence, personal visits were made to all points which were thought likely to furnish materials suitable for this purpose, and arrangements were entered into for the supply of suitable exhibits. The following list will indicate the nature of the articles obtained :— Specimens for Paris Exhibition

Iron.—Hematite—Jacksontown, Carleton Co.
Limonite—Bog iron—Sunbury Co.
Nickel—Pyrrhotite—(nickeliferous)—St. Stephen.
Antimony—Stibnite—Prince William, York Co.
Manganese—Pyrolusite—Markhamville, Kings Co.
Wad—Dawson Settlement, Albert Co.
Wad—(bricquetted) Dawson Settlement, Albert Co.
Bituminous Coal—Grand Lake, Queens Co.
Albertite—Albert Mines, Albert Co.
Bituminous Shale—Caledonia, Albert Co.
Peat—Kouchibouguac Harbour, Kent Co.
Red Granite—St. George, Charlotte Co.
Black Granite—(mica-diorite)—Bocabec, Charlotte Co.
Gray Granite—Spoon Island, Queens Co.
Freestone, gray—French Fort Quarry, Newcastle, Northumberland.
Freestone, red—Sackville, Westmoreland.
Freestone, brown—Wood Point, Westmoreland.
Freestone, olive—Rockport, "
Limestone—Randolph, St. John Co.
Millstones and Grindstones—Newcastle, Northumberland Co.
Pulp-stone, Scythe-stones, &c. " "
Serpentine marble or Verde antique—St. John.
Marble—White dolomite—Randolph, St. John Co.

New Brunswick—*Cont.*

Graphite—Suspension Bridge, St. John Co.
Dolomite, for use in pulp manufacture—St. John
Infusorial Earth—Land's End, Kings Co.
Gypsum—Hillsborough, Albert Co.
Salt and Brine—Penobsquis, Kings Co.

Notes on mineral industries.

'To this enumeration may be added a few notes respecting the present condition of the deposits represented and their mode of presentation :—

Iron.

'*Iron.* Nothing is at present being done in the production of iron. The principal specimen sent to the exhibition was a large block of hematite from the well known deposits near Jacksonville, in Carleton county, formerly worked and still commonly known as "Woodstock ore." The associated specimen of bog-iron represents the large bed of such material found near Burton in Sunbury county, and of which more or less was used in the manufacture of the Woodstock iron.

Nickel.

'*Nickel.*—Since the publication of the report upon the mineral resources of New Brunswick (1898), wherein full particulars are given of the occurrence and composition of the nickeliferous pyrrhotites of St. Stephen, attempts have been made to obtain further information as to the value of the latter. A considerable quantity was in the first instance sent to England to be treated upon a large scale. The result was unsatisfactory, the percentage of nickel being deemed too small for profitable extraction; but as this percentage was also somewhat variable, the belief was entertained that by further exploitation, ores might be found capable of affording a better yield. To test this point, orders were given for the sinking of trial shafts to a considerably greater depth than had previously been reached, and it was from one of these that the block sent for exhibition was obtained.

Antimony.

'*Antimony.*—The deposits of this metal at Prince William, in York county, still remain unworked, though negotiations with a view to the purchase and development of the property have been made. The specimens forwarded for exhibition are pure stibnite, and fairly represent the quality of the ore, of which, no doubt, an abundance exists. Specimens of native antimony, such as were found during the prosecution of the work, cannot now be obtained.

Manganese.

'*Manganese.*—The specimens sent from Markhamville are a good representation of the very rich ores formerly mined in that locality, but in connection with which no recent work has been done.

'The ore from Dawson setttlement, on the other hand, though only bog-ore or wad, is now being extensively removed, its value being found in its adaptibility, when compressed into bricquettes, for the manufacture of ferro-manganese and steel, for which purpose it has during the last

year been sent to the iron works at Bridgeville, N.S. The machinery first erected for the treatment of the ore having proved inadequate in some respects, an enlargement of the latter is in contemplation or has already been introduced. New Brunswick—*Cont.*

'*Bituminous coal.*—No important change in the conditions or amount of output has occurred during the last year, the vicinity of Grand Lake in Queen's county being the sole source of supply. The general question, however, of possible coal-production over other parts of the New Brunswick coal-field has received considerable attention, and will be made the subject of discussion in the report of which this is anticipatory. The facts obtained all emphasize the necessity of systematic borings along the eastern sea-board of the province, or along the line of the Intercolonial Railway, as affording the only possible way of removing all doubt as to the nature and capacity of the coal measures in that region. Coal.

'Borings for coal at Dunsinaine have been continued, but at new locations, and are still in progress. In one of the borings thus made two seams of coal were passed through, one of 24 inches, at a depth at 170 feet, the other of 26 inches, at a depth of 183 feet. The former, on incineration left 19·56 p.c. of ash, the latter 38·59 p.c., as reported by Dr. Hoffmann.

'*Albertite.*—No actual mining of this interesting material has been undertaken during the past year, nor are any facts known which would warrant any considerable expenditure in this direction. In connection, however, with the explorations undertaken by the New Brunswick Mining Association, with a view to determine the presence or otherwise of petroleum, the supposed original condition of the albertite in southern New Brunswick, numerous interesting observations relative to the substance have been made, and, it is hoped, may be available for a later report. They tend to confirm the views previously expressed by the officers of the Geological Survey, as to the origin, condition of occurrence and distribution of the mineral in question. Albertite.

'*Bituminous shale.*—Interest in this substance has also been revived during the past year, and considerable quantities have been removed for export, the company formed for this purpose being known as the Baltimore Coal Mining and Railway Co. It is proposed to test its capacity, not only as an oil-producer, but in connection with the manufacture of cements and in other ways. Bituminous shale.

'The explorations referred to above, in connection with albertite and petroleum include the study of the bituminous shales, which are,

New Brunswick—*Cont.*

as far as known, the source and carriers of both. As, however, albertite is found not only below the shales in pre-Cambrian rocks, but also above them, penetrating Lower Carboniferous gypsums as well as sandstones of the Coal Measures, it is hoped that places may be found where, owing to the non-removal of the sandstone or other cappings originally confining the petroleum, the latter may have escaped oxidation, and thus have been left in its original fluid condition. For the purpose of testing this point, boring operations have been and are now being carried on in the vicinity of Moncton.

Granite.

'*Materials for the purposes of construction.*—The granite industries at St. George have, during the last year, been more than usually active, a fact which made it somewhat difficult to obtain therefrom adequate representation for the Paris Exhibition. It was hoped that as a result of a meeting held in St. George in May, at which representatives of the several companies working in that place were present, a large trophy to which each company should contribute, would be prepared, but owing to the presence of other engagements, this was subsequently found to be impossible, and the desired representation was left to Messrs Milne, Coutts & Co., by whom, however, a very creditable exhibit is made.

'In addition to the special exhibit referred to above, cubical blocks of red granite, six inches to the side, and variously dressed and polished, together with similar exhibits of gray and so-called black granite, were also forwarded. Freestones were represented by dressed blocks of standard size, from the more important quarries in Westmoreland and Northumberland counties. Among them the red freestone from the Wood Point quarries, near Sackville, represents a newly opened deposit, and a rock whose rich colour has already created for it a considerable demand. It was used in 1897 for the construction of the new armoury in Halifax, and more recently for some large buildings in Moncton.

Limestones.

'In this connection reference may be made to the ornamental limestones, &c., found in the neighbourhood of St. John. In addition to ordinary gray limestone, sometimes used for building, they include white and cream-coloured marbles (dolomites) and serpentine-marble or ophiolite.

Dolomites.

' In the preceding remarks reference has several times been made to the occurrence of dolomites in the neighbourhood of St. John. Much interest has, during the last year, been aroused in these from the possibility of their being suited for use in connection with the manufacture of wood-pulp. Some time was therefore devoted to the determi-

nation of whether or not among the limestones occurring in that vicinity, any could be found carrying a sufficient percentage of magnesia to make them suitable for such use. The result was very satisfactory, for while at each of the great quarries which have been so long worked as a source of limestone for calcination, the rock is a nearly pure calcic carbonate—95 to 99 per cent, with only a trace of magnesia, these were found to be associated at several places with considerable beds, usually white or creamy instead of gray, which are decidedly dolomitic. Thus a sample of rock from Randolph and Baker's quarry, in Randolph, gave to A. E. Macintyre, F.C.S.: New Brunswick—*Cont.* Analyses.

Calcium carbonate ($CaCo_3$)	62·85
Magnesium carbonate ($MgCo_3$)	35·32
Iron, alumina, silica undetermined	1·83
	100·00

'Other specimens from the same locality, examined in the laboratory of the Survey, proved to contain close on 45 per cent of magnesium carbonate; the proportion characteristic of true dolomite. There would therefore seem to be no reason, so far as chemical composition is concerned, why portions of these rocks should not satisfy all the requirements of pulp-making. As, however, in connection with the inauguration of the large pulp mills at Mispec, it was not thought desirable to commence operations with untried materials, and large amounts of dolomite had been imported from Ohio, the practical tests necessary to place their fitness beyond doubt have not yet been made. It is to be hoped that this will soon be done, as there can be no doubt that the amount of such material about St. John is very large, and that if found suitable for use, a very great saving may be effected. Use in wood-pulp industry.

'*Infusorial earth.*—Specimens of this material were obtained during the past summer from one of two small lakes occurring near the south-west extremity of the Kingston peninsula in Kings county. In a visit to one of these, known as Longs Lake, by the writer, the whole bottom of the lake or pond, having a length of about 1,000 feet and an average width of 600 feet, with a depth varying from 2 to 10 feet, was found to be composed of this material, into which a pole could be readily thrust in places to more than 10 feet and almost anywhere to a depth of 6 feet. The material is light-gray when wet, becoming almost white upon drying, and very adhesive. It is not, however, as judged from the samples selected, sufficiently pure to serve the purposes of tripolite, there being a considerable admixture of clay. In Telegraph Lake, near by, is a similar Infusorial earth.

New Brunswick—*Cont.*

deposit, and both are most favourably situated for removal, that first described being within a mile of the shore of the St. John River, and capable of easy drainage.

Gypsum.

'*Gypsum.*—The operations connected with the working of this material have, as in former years, been confined to the vicinity of Hillsborough, in Albert county, and have been upon the usual extended scale. Specimens fully representative of the different grades of rock, including cut blocks of very pure alabaster, as well as of land-plaster, plaster of Paris, terra-alba, &c., have been prepared by Mr. C. J. Osman, M.P.P., manager of the Albert Manufacturing Company, and forwarded for exhibition.

Investigation of age of slate belt.

'After the completion of the work required in connection with the exhibition, the remainder of the season was, devoted to the study of the principal unsolved problem of New Brunswick geology, viz., the age of the great bands of slates and associated rocks lying upon either side of the granites of York county, rocks in which interest had been renewed, first, by the discovery in the previous season, by Mr. Wilson, of the Geological Survey, of fossils indicative of a Silurian horizon in an area previously regarded as Cambro-Silurian, and, secondly, from the reported discovery, in connection with one of these belts, of auriferous veins, in the parish of Stanley.

Discovery of Silurian fossils.

'The first of the questions cannot here be discussed at length, but the general statement may be made that, while much important information has been obtained bearing upon the strategraphy of the region, and the strata in a few instances have been found to be fossiliferous, the question as to how many systems are represented here and their separation, still remains in doubt. To the discovery of Mr. Wilson of

Localities.

brachiopods, &c., in slates a few miles north of Canterbury station on the Canadian Pacific Railway, we have now to add that of crinoids, corals and bryozoa in the limestones of Waterville, in the parish of Southampton, nearly fifteen miles distant from the former, and apparently indicating a similar (Silurian) horizon, but in a so highly metamorphosed condition that nearly all distinctive features of the inclosed organisms have been lost. On Spring Hill brook also, five miles above Fredericton, slates, alternating with quartzites, and in every way similar to those which form the larger portion of the southern slate belt of York county, have been found by Mr. W. T. H. Reed to contain impressions in the form of smooth black surfaces marked with five striations, hexagonal areolations or both; but these again are so obscure as to throw little or no light upon the age of the beds containing them. Dr. Ami, to whom the specimens have been

referred, says of them that they bear certain resemblances to Ostracoderms, which would lead one to suspect that the rocks are Silurian. Should this be the case and this locality be added to those of Canterbury, Waterville and Rocky Brook, on the Nashwaak, in which Silurian or Lower Devonian fossils were found some years ago by Mr. Chas. Robb, we shall have four widely separated localities within the areas under review in which fossils more recent than that of the age to which these have been assigned, are known to occur. Yet every observer who has examined this portion of New Brunswick, including Logan, Hind, Robb, Matthew and Ells, has regarded the slate bands in question as being, upon the whole, distinct from that of the easily recognizable and highly fossiliferous group of Silurian rocks that lies to the northward in Carleton and Victoria counties. It must also be remembered that distinct proof of the existence of Cambro-Silurian rocks along the line of contact of the two contrasted groups is found in the Beccaquimec valley, in the occurrence of strata carrying such fossils as *Trinucleus seticornis*, *Harpes*, *Acrotreta*, *&c.*

New Brunswick—*Cont.*

Fossils of Cambro-Silurian age.

'Stratigraphically also, the work of the last summer tends strongly to confirm the view, enunciated in the Report of 1885, that not the Beccaquimec limestones only, but the great bulk of the strata stretching westward towards the Maine boundary, lie unconformably beneath the Silurian system. According to this view the fossiliferous slates of Canterbury (found by us to be also fossiliferous at Eel River) and the crinoidal limestones of Waterville represent areas of Silurian included in more or less open folds of older and much more intensely altered strata.

Relations of two series of rocks.

'In connection with the investigation of these questions, some time was spent in the examination of the so-called Cross Creek gold district in the parish of Stanley. In view of the fact that the first discoveries, made in the early spring of 1898, involving the display of numerous fine specimens and the creating of a fever which led to the investment of over $2,000 in the taking out of prospecting licenses, have never been followed by systematic exploration or expenditure and that nearly all interest in the region has now abated, it would seem that but little real foundation and not a little fraud was involved in some of the earlier statements made. The investigations of the writer led him not only to visit the first reported locality at Cross Creek, but also Rocky Brook, McLean Brook and Ryan Brook, tributaries of the Nashwaak above Stanley, as well as the Taxes River, a branch of the Miramichi. The strata, which are very similar upon all of these streams, include massive quartzites, purple and gray slates and black pyritous slates, thus resembling the

Gold reported at Cross Creek.

New Brunswick—*Cont.*

rocks of the auriferous districts of Queens and Lunenburgh counties, Nova Scotia, and contain numerous veins of quartz; but their relations are obscured by excessive folding as well as by an extensive covering of superficial deposits, while the quartz veins are mostly small and irregular, forming no well-defined lodes, and as far as the writer could ascertain, without gold. There would seem to be but little question that some gold has been found here, as over many other portions of northern New Brunswick, but the existence of anything like a true gold district is yet to be proved.

Materials for road making.

'I have only to add that, by your direction, some little attention was paid to the question of the existence and location of materials suitable for the macadamizing of roads. In the case of the city of St. John, extensive deposits of trappean rock, apparently suitable for this purpose, were noted in the vicinity of the Martello tower, in Carleton, as well as near the old penitentiary building east of Courtney Bay, and by the advice of Mr. W. F. Burditt, of the Good Roads Commission, with whom the localities were visited, the crushing plant of the city has been placed at the point last named. Yet here, as elsewhere, present cost rather than future stability seems to be the principal factor in the choice of materials, the necessity in the case of St. John for the removal of so much stone for the excavation of foundations and the grading of streets, constantly affording a very cheap, though often a very unsuitable material for such use. In Fredericton a variety of diabase, found in the vicinity, is now extensively employed, and is giving good results. Offers for the sending up of samples of this rock to be submitted to experimental tests in the physical laboratory of McGill University were made, but those having the matter in charge preferred to be guided by the results of their own experience.'

NOVA SCOTIA.

Work by Mr. H. Fletcher.

Mr. H. Fletcher was engaged during the winter of 1898-99 in plotting the surveys made in Cumberland county referred to in the Summary Report for 1898, pp. 139 to 148, and in revising those made by his assistant, Mr. M. H. McLeod, in connection with the preparation of several sheets of the geological map of Nova Scotia.

On June 16 Mr. Fletcher left Ottawa for field-work in Nova Scotia, and did not return to Ottawa until January 8, 1900. On the work done, Mr. Fletcher makes the following report:—

Assistants.

'I was again assisted by Mr. McLeod and also by Mr. Colin McLeod, of Springhill, who were engaged in making surveys necessary

to complete map-sheets 59, 60, 61 and 62 adjoining the Springhill sheet, and who surveyed the various brooks above the Florida road to their heads in the pre-Carboniferous rocks, the northern limit of the latter being a short distance south of that road. Many of the tributaries of the Wallace and Pugwash rivers they also surveyed by pacing, and nearly all the roads of the district by odometer. The general relations of the various groups of rocks have been already pointed out by Dr. Ells. Nova Scotia —*Cont.*

'My own work consisted chiefly of a study of the south side of the Springhill coal-field. I have great pleasure in acknowledging assistance received in this work from Mr. R. Cowans, General Manager of the Cumberland Railway and Coal Company, from Messrs. C. and J. Hargreaves, John Murray, Ben. Parsons, Harvey Howard, A. H. Alloway, E. Laflamme, Geo. Hall, R. H. Cooper, and other officials of that company; from Messrs. William Hall, M.E., mayor, Dan. McLeod, town clerk, and John Anderson, post-master, of Springhill; from Peter Nelson, John E. Bishop, H. H. Card and Blair O'Rourke, of Springhill; from Rufus and Levi Gilroy, Wesley Herrit, Thomas Boss and Alex. Stewart, of Rodney; J. W. Broderick, of Lower Five Islands, Charles E. Day, of Parrsboro, and others. Owing to the untimely death of G. W. McCarthy, on June 7, I lost his invaluable assistance in this field. Acknowledgements.

'Sixty borings, by a hand drill ranging in depth from a few feet to one hundred and forty-six feet, together with several trenches and pits, have been made in an attempt to define the course of the coal-seams known to exist in this vicinity and their relation to the red and purplish strata of the head of the South Branch of Black River and of the north-east fork of the Upper Maccan River and the conglomerate already referred to.* Springhill coal field.

'It has long been a debatable question with the miners whether these red rocks lie above or below the worked coal-seams, and it cannot be said that this relation has been yet satisfactorily defined, although thus far no stratigraphical evidence seems to have been obtained to contradict the assumption that they overlie, except the small disturbance of strata caused by the great faults required to bring the red strata down perhaps more than 1,500 feet into juxtaposition with the large coal-seam supposed to be that of the West Slope. But this difficulty may be lessened by an unconformity, already hinted at as probable, above this horizon, such as is shown by Dr. Ells often to occur between the Permo-Carboniferous and underlying rocks but has not yet Relation of coal-seams to red beds.

*Summary Report, Geol. Surv. Can., 1898, page 146.

Nova Scotia —*Cont.*

been worked out in this vicinity. The red rocks differ only in colour from the strata underlying the coals, the composition and texture being the same ; but this may also be said of most parts of the great section at the Joggins and no red strata have been seen underlying the coal in the sections at Springhill mines or lower down the South Branch, not more than three-quarters of a mile north of the red rocks in question, with the exception of one layer not far below the seam at McCarthy's slope. The red rocks here include a coal-seam* which is perhaps also that of Maccan River near the Leamington Orange hall and that bored into at a depth of 488 feet in the deep bore-hole at Mapleton. The sections may thus be identical. That at Mapleton is not far from strata referred by Messrs. Scott Barlow and Walter McOuat to a horizon above the Coal Measures, and I would suggest tracing it into connection with the latter, with some of the small coal-seams proved to run past the mine levels, or to the great fault that must separate them if the red rocks underlie the Coal Measures.

Coal seams among the red rocks.

Tracing out of large seam.

'The large seam of the bore-hole described at page 145 of the last Summary Report, was traced south-westward by borings and shallow pits for a distance of sixteen chains, crossing the road to Gilroy's sugar camp, at which a pit proved the dip to be N. 75° W. at right angles to the line traced by boring. The seam, although it maintains its thickness, has here greatly deteriorated. On a more westerly course coal *débris* was found for six chains further in the heavy surface, but, a short distance beyond, the seam appears to come against a fault, which, if the same as that proved to the north-westward on the east bank of Sugarwood Brook, has a dip of S. 4° E. $< 52°$, and is therefore, if normal, a downthrow to the south.

'In the red rocks six chains to the south-westward, a coal-seam, lying horizontal, has been traced for about nineteen chains parallel to the fault, at right angles to the large seam and close along the south bank of the South Branch. Red strata occur along this river to the old Rodney road, were bored in 1874 at the watering trough on the main road, and follow the Upper Maccan River through Leamington and Mapleton, as before stated. Near Rodney they are cut in Burton Boss' well and are succeeded by the conglomerate of Rodney and of Polly Brook.

Faults.

'A curious feature of the eastern outcrop of the large seam, is that red strata follow it on the east side so closely to the rise that the bottom of the seam has not room to reach the surface. This apparently indicates a north-east and south-west fault, details of which could not

*Summary Report, Geol. Surv. Can., 1898, p. 146, line 20.

be obtained; for, while the gray beds associated with the coal to a depth of sixty-four feet in No. 15 bore-hole are regular, the red are horizontal and cut by V-shaped joints. Nova Scotia —*Cont.*

'South of the main east-and-west fault and immediately north of the South Branch of Black River, another downthrow to the south shows, on its north side, red strata apparently from beneath the greenish and gray rocks associated with the coal-seam. These faults appear to be parallel to that near the Syndicate slope, which is also a downthrow to the south or a thrust to the eastward on the south side. The Syndicate fault has not been proved to the eastward, but its position may be indicated by the slight discordance of strata immediately west of McCarthy's slope; also north of the pits at the head of Sugarwood Brook.* None of these faults produce much disturbance of the strata adjcining them.

'South-westward down along Sugarwood Brook from these pits, there is apparently no east-and-west fault for twenty-one chains to a branch from the eastward. Here at the foot of the right bank, bore-hole No. 39 was put down 146 feet through gray strata with one seam of coal, which presumably overlies the large seam a considerable distance. From the forks up the most northerly of the two little brooks into which the branch from the eastward breaks, the rocks resemble those bored and trenched in the South Branch and must overlie the gray fine sandstone above the large coal-seam, unless there be faults not yet detected. The horizontal strata pile rapidly up at the falls (where a six-inch band of hard slaty coal is seen) and are well exposed to within sixty feet of the bridge on the sugar-camp road. In the adjoining branch and in other tributaries of the neighbourhood, a thickness of fifty feet of horizontal rocks is in places exposed. About three chains from No. 39 bore-hole down stream, on the left bank, the main fault above referred to was uncovered, the rock on the north side being a gray sandstone with patches of conglomerate, similar to the strata overlying the large coal and also, in the multitude of glistening points of quartz, like the sandstones of Ragged Reef. As already stated, the dip of the well polished face of this sandstone is S. 4° E. < 52, while at fifty feet to the south-westward red and green rocks are greatly shattered into irregular blocks, traversed by veins and films of calcite, ankerite and hematite; some of the planes are curved but without definite direction; the dip seems to be steeply south but is obscure, for a thin lenticular seam of coal dips for a short distance N. 83° W. < 25°, in which direction it breaks into two layers, the uppermost being nearly horizontal. Westward from Sugarwood Brook, this fault seems to pass Rocks on Sugarwood Brook.

*Summary Report, Geol. Surv. Can., 1898, pp. 143, 144.

Nova Scotia —*Cont.*

through the graveyard on the old Rodney road, to follow South Branch and the Rodney road as far as the sharp turn to northward at the slaughter-house (where the dip is steep and a change of strike occurs) and to cross Harrison Brook about ten chains below the Leamington road, where it appears to dislocate the Claremont anticline, or repeat it at two points, one of which is five chains above the road, the other twenty-two chains below it.

Overlying seams.

'From a point on Sugarwood Brook about midway between the outcrop of the large seam and borehole No. 39, the gray sandstone with coarse layers, supposed to overlie this seam, as already stated, was traced northward about fifteen chains to the head of Gilroy Brook and down along the north bank, from which it gradually recedes as if to join the outcrops of similar rock north of Alex. Stewart's (Jos. Herrit of Barlow's map of 1874*), about one mile to the westward. Immediately south of and overlying this sandstone, a small seam of coal was opened on the left bank of Gilroy Brook dipping south $< 12°$. This was sought and bored on the old Rodney road immediately north of Gilroy's house, where the dip apparently indicates an extension of the coal basin still further to the southward. As the outcrop of the sandstone and of the coal both seemed to point to the equivalence of the latter with a bed opened, many years ago, on the road near the slaughter-house above referred to, and said to contain twenty inches of good coal, a boring was made, intermediate between the two outcrops, at the road immediately west of Alex. Stewart's house. In it a coal, probably the same, was again found, underlain by a heavy band of gray fine and coarse sandstone.

'West of the slaughter-house this coal was not followed, but I might suggest the possibility of its being the Golden seam, three feet eight inches of coal and shale where it was opened by us, a year ago, on the Leamington road, fifty chains south-west from Miller's Corner, on the opposite side of the Claremont anticline, the underlying North Slope seam being perhaps that found in a pit at Lemuel McNutt's gate on the Rodney road.

Mr. Barlow's general section.

'In Mr. Scott Barlow's general section of the Springhill district, of which that given in the Report of Progress, 1873-74, page 157, is a part, no red strata are mentioned for 1,849 feet from the bottom up to the West Slope seam. About 680 feet higher, or 330 feet above the North Slope or No. 3 seam, however, red beds, like those of the bore-holes, begin; while about 515 feet above No. 3 is a four-foot coal (the Golden seam), perhaps that bored in the South Branch of Black River.† The seam called on Mr. Barlow's plan the highest (workable ?)

*Published in Walker & Miles' Atlas of the Dominion.

†Summary Report, Geol. Surv. Can., 1889, page 146, line 20.

in the field lies 1,000 feet above No. 3, also among red strata, and at 1,235 feet a two-inch coal seam is included in gray sandstone and shale. Nova Scotia —*Cont.*

'It has been stated that the coal of the 48-foot bore-hole near Sugarwood Brook differs in section from that further south; it is, therefore, possible that the latter may be a distinct seam, perhaps No. 3, in which case a smaller fault might bring red strata into immediate proximity with it, as at the bore-holes. To test this a close comparison should be made of the two seams.

'Comparing the borings of 1898 and 1899 with those made before 1874, shown on Barlow's map, the rocks of Harper's bore-hole, 386 feet deep, may be those cut last season, Harper's bore-hole lying apparently far within the outcrop of the highest seam and the red layers, masses of gray sandstone and streaks of coal corresponding closely in both sections. Roberts' bore-hole, 176 feet deep, also cut red strata and two smaller seams of coal. The coal of the top of the bore-hole, 715 feet deep, at the watering-trough north of Captain Mills', suggests the position of Barlow's highest seam; and the seam bored at 488 feet from the surface will then be almost exactly in the position of the four-foot seam, the Golden seam of the Leamington road. The tracing of this latter from that road into the basin of Maccan River might determine this important point. Comparison of results.

'The bore-hole, 320 feet deep, south of Miller's Corner, seems to indicate a block of faulted, steep-dipping rocks among the flat strata adjoining, if the two seams mentioned in the section as cut 210 and 270 feet from the surface be those shown on the plan as cropping out 500 and 600 feet to the rise of the borehole, on the horizon apparently of No. 3 seam.

'From July 9 to July 14, I was in Cape Breton with Dr. G. F. Matthew, who was working on the Cambrian and other old rocks of Long Island, Barachois, Boisdale, East Bay and Mira, the oldest fossiliferous deposits of Cape Breton, similar to those in New Brunswick and Newfoundland, also studied by Dr. Matthew.* Cambrian of Cape Breton.

'At the end of the year, another short visit was paid to Sydney to obtain particulars concerning recent developments of mineral deposits, more especially in relation to the erection on the east side of Muggah Creek of furnaces for the production of iron and steel.

'In August, four days were spent on an examination of the Devonian rocks of Five Islands and Lower Economy. A section was made of 3,928 feet of the fine plant-bearing exposures of Harrington River, so that Five Islands.

*Bull. Nat. Hist. Soc. of New Brunswick, xviii, vol. iv, p. 198.

Nova Scotia —*Cont.*

there need be no question of the stratigraphical horizon of these rocks, which have hitherto been made to include all the geological formations from the Cambro-Silurian to the Coal Measures, and even the Permian. The upper red series is not so well exposed in this river as the lower gray and blackish shales and quartzites, but appears at many points below the bridge on the shore-road, is in cliffs along the adjoining North River and comes upon the shore at Lower Economy, precisely like the red strata of McAra Brook and yielding a small quantity of manganese ore, like the strata of that age at East Mountain of Onslow.'

Work by Mr. E. R. Faribault.

Mr. E. R. Faribault was engaged during the winter months of 1898-99, in preparing for publication the surveys of the preceding summer, including plans of the gold districts of Waverley, Montague, Cow Bay, Lawrencetown, Lake Catcha and Tangier, in the county of Halifax.* Some progress was also made in the compilation of the map-sheets on the scale of one inch to the mile, lying immediately west of Halifax.

At my request, Mr. Faribault also undertook the construction of a series of longitudinal and transverse sections of the Goldenville gold-district, to form the basis of a model of this important district as typical of others in Nova Scotia and for the forthcoming exhibition at Paris. The work has proved to be a somewhat difficult one, but when completed the model will clearly illustrate the "saddle-vein" structure so characteristic of the Nova Scotia deposits, as well as the position and conditions of the portions of special enrichment of the several superposed veins. These zones of enrichment extend probably to great depths in a direction approximately parallel with the axial plane of the fold, and may easily be determined by systematic and well-directed development.

On the work accomplished in the field during the past summer, Mr. Faribault reports as follows :—

'In compliance with your letter of instructions, dated June 2, I left Ottawa on June 13, for Nova Scotia, to resume the surveys of previous years in connection with the mapping and study of the structural geology of the gold-bearing rocks of the Atlantic coast of that province.

Field work.

'I was again accompanied, during the whole season, by Messrs. A. Cameron and J. McG. Cruickshank, who have been my assistants for fifteen and thirteen summers, respectively. I have to thank many

*Summary Report, Geol. Surv. Can., 1898, pp. 148 to 159, for description of the districts.

persons for information and assistance, especially the Hon. Charles E. Church, Commissioner of Public Works and Mines, Dr. Edwin Gilpin, Inspector of Mines, and Mr. F. H. Mason, F.C.S., of Halifax; Professor H.Y. Hind, Mr. Clarence H. Dimock, and Mr. W.H. Blanchard, of Windsor; Mr. Evan Thompson, of Elmsdale, Mr. Matthew Thompson and Mr. Geo. Ralph, of Renfrew; Mr. John J. Withrow, of South Uniacke: Mr. Samuel Mitchell, Mr. T. R. Price, Mr. Wm. Hayes, of Mount Uniacke; Mr. Bernard Macdonald, M.E., Manager Le Roy Mine, Rossland, B.C.; Mr. E. A. Daly, Manager Dufferin Gold Mine; and Mr. T. G. McNulty, Manager Tunnel Gold Mine, Waverley. Nova Scotia —*Cont.*

'A revision has been made of the structural geology of the gold-bearing rocks of that portion of Hants county covered by the Kennetcook sheet, (No. 65,) the Enfield sheet, (No. 66,) and that portion of the Windsor sheet, (No. 73,) surveyed in 1892 and reported on in the Summary Report for that year at pages 37 and 40. All the field-work necessary for the geological mapping of that region has been completed and most of it has been plotted. Gold-bearing rocks of Hants county.

'Mr. A. Cameron was engaged, from September 12 till October 20, surveying with the prismatic compass and odometer most of the roads situated in the gold-mining region of Queens county, with a view to producing complete maps of that district at an early date.

'Special detailed surveys have been made of the gold-mining districts of Renfrew, Mount Uniacke and South Uniacke, situated in Hants county, in the region surveyed for the Windsor sheet, (No. 73,) with a view of preparing large-scale plans of them, similar to those already published for Guysborough and Halifax counties.

'*Renfrew Gold District.*—Three weeks were devoted to a detailed survey of this district, and a plan on the scale of 500 feet to 1 inch has been plotted and compiled in the field. This district occupies the summit of a low watershed that separates the valley of the Shubenacadie from the Bay of Fundy, and it is situated four miles north of Enfield, a station on the Intercolonial Railway, twenty-seven miles distant from Halifax. Renfrew gold district.

'The auriferous quartz veins which have been worked from time to time, since the first discovery of gold in 1861, all belong to the class of segregated, interbedded veins, occupying spaces along the planes of stratification on the dome of a huge anticlinal fold. This anticline is the continuation from the west of the Mount Uniacke anticlinal

Nova Scotia —*Cont.*

fold, and its general course is N. 70° E. (mag.)* It crosses Stinking Lake, which marks the western limit of the district, about the middle, and running eastward it follows Number-eight Brook down to Nine-mile River and reaches Little Nine-mile River where the gold-bearing rocks are covered by Carboniferous strata.

Character of the anticline.

'The form of the fold is that of a slight overturn to the south, and it is the broadest and most flattened elliptical dome that has yet been met with in the eastern part of the province. Extensive erosion has worn away and truncated this fold to a known depth of 13,700 feet, exposing at the present surface a horizontal section of strata of the quartzite division and intercalated veins, which were originally deposited 8700 feet below the base of the slate division of the gold-bearing series.

'The strata lie at low angles for some distance on both the north and south sides of the fold, the dip increasing gradually till it reaches 50° at a distance of 2,500 feet to the south of the axis, and 65° at a distance of 5,000 feet; while on the north leg of the fold, the dip reaches only 30° at a distance of 2,500 feet, and it does not exceed 45° further north, giving to the axis-plane of the fold a dip to the north of 75°. At the western end of the district ridges of thick beds of hard quartzose sandstones stand out in bold relief for many hundred yards; near Stinking Lake they curve around the western extremity of the

East and west ends of dome.

elliptical dome, describing long undulating and faulted curves, and pitch to the west at angles varying between 18° and 25°. At the eastern extremity of the dome, in the vicinity of the Nine-mile River, the strata curve more abruptly round the anticlinal axis and they pitch to the east at an angle of about 20°. The centre of this broad dome could not be exactly located, the rocks being for the most part covered by drift in the northern part of the district, but it is situated on or near Number-eight Brook and at no great distance to the east or west of lot 833, block 2.

Mining on south limb.

'All the mining operations have been carried out on the south or steeper limb of the fold and particularly on the south-westerly portion of the elliptical dome. In studying the structure of this anticlinal fold more closely, we find that three gentle undulations radiate from the centre of the dome, two in a westerly and one in a south-easterly direction. The two western undulations run on the general course of the main anticline towards Stinking Lake, with strata dipping westerly at angles under 25°. The numerous rich boulders of auriferous quartz that have been found between Stinking Lake and the Rawdon road, are derived undoubtedly from these two

*The magnetic variation in this part of Nova Scotia is about 21° 30′ west.

undulations, but all search for the leads from which they came has hitherto been fruitless on account of the great thickness of drift and boulder-clay covering them. However, the low angles at which the veins dip and the many faults affecting the strata will probably prevent important mining operations. Nova Scotia —*Cont.*

'The south-western undulation, which is by far the most important of the three, begins at the centre of the dome and widens out in a south-westerly direction, pitching to the south-west at an angle gradually increasing from 0° at the centre to 50° at the extreme limit, and the axis-plane dips north at an angle probably near 75°.

'On the north-western side of this undulation, the measures have been subjected to enormous strain and shearing, producing a series of right-hand faults roughly parallel with the axis of the undulation and giving horizontal displacements ranging from a few feet up to 200 feet. Numerous veins have been uncovered on this side of the undulation and many have proved auriferous, but they are so discontinuous and cut up by faults that it is very doubtful if they can ever be extensively worked with profit. One very rich streak was discovered in 1897 on a vein called the Jubilee lead, and a shaft sunk to the depth of 65 feet showed the streak to dip west about 50° and to follow the shoulder of a small local undulation in the faulted measures. I was informed that three tons taken from a part of this streak had given $5,000 worth of gold and that the 80 tons of ore extracted and still lying at the pit were valued at about $60 to the ton. There is undoubtedly a zone of special enrichment crossing the veins along the north side of this undulation, and passing probably in the vicinity of the Jubilee and Walker shafts. The rich float of auriferous quartz discovered on Parker Brook and Rawdon road, immediately north of the bridge, originated no doubt from veins situated on this zone. Faulted tract.

'The south side of the south-western undulation contains the most extensively operated veins of the district. On the south side of the dome, opposite the centre, the strata run on a straight course parallel with the axis of the main fold, and they have been tightly compressed in the process of folding by a direct lateral force from the south which has prevented the formation of fissures. But, as they approach the south-western undulation, they curve gradually round, and, coming under the influence of a powerful shearing force, develope in some slate belts numerous fissure-veins. The veins gradually increase in size and in number, until they attain their maximum width on or about the apex of the undulation, forming a zone of fissure-veins which possesses all the characteristic features of a promising field for permanent and South side of south-western undulation.

Nova Scotia —*Cont.*

deep mining. Important streaks of special enrichment have been worked on many leads along this zone. They are generally well-defined and dip to the west at an angle of about 45°, corresponding to the pitch of the crest of the undulation, and, as far as present operations have gone, we find that they crop out at the surface along a well-defined line. This line of special enrichment runs from the centre of the dome, on Number-eight Brook, S. 47 W.° (mag.) to Parker Brook, some 500 feet below the Rawdon road bridge, thence curving to the south it crosses the Renfrew Brook about the Colonial dam and extends to the works on the Andrews lead, which marks about the extreme south limit of the formation of fissures, on lot 1826, block 1, giving a total length of 8,500 feet.

'In the first 4,600 feet, from the centre of the dome to the Phillips lead at Parker Brook, some thirteen leads have been uncovered, most of them recently, all lying at angles under 40°, many of which have proved auriferous and promising, but none have so far been operated.

Section of auriferous veins.

'The next 1,600 feet of the zone, south of Parker Brook, includes a succession of twenty-two known veins, comprised between the Phillips and the McClure leads, most of them included on the property of the Pictou Development Company. Their length varies from 200 to 1,000 feet, and their average thickness is above that of the veins in most districts in the province. Proceeding from north to south, the veins on which most mining has been done come in the following order and at distances stated from the McLeod lead :—

Leads.	Thickness in inches.	Distance from McLeod lead in feet.	Deepest shaft in feet.	Length opened in feet.	Remarks.
McLeod....	9 to 15	0	360	1,350	Two rich streaks, eastern one dips east, western one west.
Preeper	10 to 36	95	125	800	Good strong lead.
Foundation.	5 to 10	150	400	600	Rich lead, traced west a long distance.
Hay	9	210	120	600	
Paper Collar	6	285	150	300	
Kilcup.	10 to 16	380	50	1,000	
Clements...	10 to 24	460	75	600	Good large belt.
Sims.	10 to 48	655	112	1,200	Good large belt of constant value.
Johnson....	8 to 36	960	90	1,000	
North Ophir	12 to 18	1,370	350	1,000	Belt of four leads, rich streak dips west.
South Ophir	8 to 12	1,510	400	800	Rich pay-streak dips west.
McClure....	12 to 15	1,585	185	500	Slate belt with quartz.

'The remaining 2,300 feet of this zone, between the McClure belt and the Andrews lead, contain, as far as the the surface developments have gone, only ten leads and none have proved of special value.

Rich drift has, however, been found in this section, south of Renfrew Brook, but it may come from the leads worked further north. Nova Scotia —*Cont.*

'Outside of the middle section of this zone of special enrichment, the only veins which have been operated to any extent are those situated on the Free-claim property on the north bank of Renfrew Brook, where a local crush of considerable interest occurs on the Free-claim and No. 2 areas, at a distance of some 5,000 feet to the south of the centre of the dome. Some ten veins have been operated which are mere local segregated sheets of auriferous quartz, occupying interbedded fissures limited to 100 or 175 feet in depth and 150 feet along their course. At this limited depth, the formation is thrown to the south about eight feet by a fault, and on the dip the measures assume their regular course. But it has not been ascertained if they still hold payable auriferous veins beyond the fault, and it is very doubtful if they do. Free-claim property.

'A series of some thirty or forty veins has been uncovered on the south-eastern flank of the dome at a distance varying between 2,000 and 5,000 feet directly south of the centre. A few of them have shown gold, but none have been operated. The pay-streaks on this zone probably dip eastward.

'On the eastern pitch of the main anticlinal fold, 4,000 feet east of the centre of the dome and half-way down Number-eight Brook, a few boulders of gold-bearing quartz have been found, but all search for the veins *in situ* has been fruitless, only a few veins of low-grade ore having so far been found. This comparatively sharp fold presents very promising features for the development of large mineralized fissure-veins, and, but for the heavy drift covering the strata, it affords a very good field of search for new veins. Eastern pitch of main anticline.

'On the north limb of the main fold, the strata lie at angles varying between 10° and 35°, rather low for the occurrence of payable veins, considering the fact that they could only be worked at a disadvantage on account of the low angle of the dip. Boulders holding gold have, however, been found in the thick drift covering this limb, and search for the veins was being made by an American company at the time of our visit.

'The total production of the district from 1862 to September 30, 1898, is 33,869 ounces of gold, valued at $660,453, extracted from 48,142 tons, giving an average yield of $13.72 per ton of 2,000 lbs., while the average of the whole province for the same period is $12.12. This average is certainly very satisfactory, if we take into consideration the inadequate appliances used for the saving of gold, especially Gold product.

Nova Scotia —*Cont.*

by the earlier companies; and, it may be further said that the mining operations have proved as a whole remunerative, although often conducted in a very unskilful manner. Operations in the district have, however, practically been suspended for some time, the only work at the time of our visit being the prospecting for new leads in the northern part of the district.

Causes of present stagnation.

'Various reasons may be assigned for the present stagnation at Renfrew and other gold-mining districts. In most of the districts the ground was formerly held in small areas, operated by individuals or small companies with limited capital, and the system of mining consisted in opening up the different veins separately, by means of shafts sunk every fifty feet along their outcrops. In Renfrew no more than 200 feet of cross-cutting have been done. By this mode of working the payable portions of the veins outcropping at the surface have been extracted to very limited depths, and we have reached a stage at which a system more suitable to deep and permanent mining has to be adopted.

Prospects for larger working.

'I may be permitted to quote here the conclusions of the Director of the Geological Survey, embodied in an article which appeared in the *National Review* for October, 1896: "The knowledge now gained of these veins renders it practicable and desirable that they should be worked in a larger way, combining series of parallel and adjacent deposits under a single management, and opening them up by means of one or two principal shafts. Much would be gained by this in economy and in the perfection of milling and concentrating machinery; and under careful management there is little doubt that the gold product of the province might be easily doubled within a few years."

Best part of district for this.

'As far as developments have gone in the Renfrew district, the 1,600 feet of section of twenty-two leads included in the middle portion of the south-western zone between the Phillips and the McClure leads, offer the most promising field for such undertakings. There is little doubt that the gold-streaks outcropping at the surface on the different veins and pitching west at an angle of about 45°, will be found to extend continuously to much greater depths, and if one thin out it will be replaced by another parallel and in close proximity to the first. These streaks extend in depth in a plane probably parallel to the axis of the undulation, dipping north-west at an angle of about 75°, and developments will have to be directed along that axis-plane to keep in the zone of special enrichment.

'The Renfrew Brook running eastward along the southern part of the district, presents several important falls and rapids between

McLellan Lake and Meadow Brook into which it runs, a distance of two miles. Five falls of about 20, 35, 15, 35 and 15 feet respectively have already been utilized for water-powers above the main road. Six lakes are available for reservoirs above these falls, and several important water powers could be established on this brook, both above and below the main road. Nova Scotia —*Cont.*

'*Mount Uniacke Gold District.*—Some three weeks were employed making a detailed survey of this district, and a plan on the scale of 250 feet to 1 inch is now completed and ready for publication. Mount Uniacke gold district.

'The district is situated on the dividing ridge which separates the waters flowing into the Atlantic from those which seek the Bay of Fundy, its elevation being 480 feet above high-tide in Bedford Basin. It is situated three miles north-west of Mount Uniacke station on the Dominion Atlantic Railway, which is distant twenty-seven miles from Halifax. Mining began in 1867 and was conducted with more or less activity for twenty years, but very little work has been done for the last ten years.

'All the auriferous quartz veins developed belong, as in the above district, to the interbedded class, and they occur on the south limb of the denuded crest of a sharp auticlinal fold. This fold is the western prolongation of that passing through the Renfrew district, from which it is distant seventeen miles; its general course in N. 81° E (mag.) and it forms a long, narrow, elliptical dome, pitching east at a comparatively high, and west at a low angle. It dips to the north at an average angle of 60°, and to the south vertically, forming a slight overturn to the south, giving to the axis-plane of the fold a north dip of about 75°. The horizon of the strata brought up on this anticline is estimated to be 12,500 feet below the base of the slate or upper division, giving a total erosion of some 23,000 feet. Interbedded veins.

'Large quartz veins occur on the centre of this dome, on area 678, block 2,250 feet north of the P.C.F. Gold Mining Company's crusher, but none of them have so far been operated, although they show mineralized bands which may prove workable.

'All the veins operated are situated on the south limb of the fold and occur along two well-defined and distinct zones of fissures. In the process of folding, the measures on the south side of the fold have been subjected to a lateral pressure and shearing causing the softer rocks and more yielding beds of slate to separate along the planes of sedimentation, developing a zone of fissure-veins running almost parallel with the anticline and at a distance of 600 feet at the west end and 800 feet at the east end of the dome. This zone is very Fissure veins.

Nova Scotia —*Cont.*

narrow, but it has a total length of some 6,500 feet or more, limited at the east end by the Alpha Brook and extending west to about area 813, block 1. It presents along its whole course only a few veins, three of which have been operated. The two most northerly, the South lead, 3 inches thick, and the Bunker lead, 4 inches, are only fifteen feet apart and have been worked at intervals by many small shafts, seldom reaching 60 feet, and by open-cuts, for a length of 3,400 feet. One pay-streak on the Bunker lead, dipping east and formed by angular veins dipping south-east, has, however, been worked on the Prince of Wales property to the depth of 200 feet.

Nuggetty lead.

'One hundred and ten feet south of the Bunker, the Nuggetty lead, four inches wide, has been extensively worked at places along its course. It was uncovered for 6,000 feet, or nearly the whole length of the district. Four important pay-streaks have been worked on the Nuggetty lead: one at the east end on the P. C. F. property, dipping east at an angle of about 35°, was worked 150 feet deep; 1,000 feet west of it another pay-streak, dipping east at an angle of 26°, was worked to the eastern limit of Mr. Henry Hogan's Montreal property, proved very rich to the depth of 247 feet and is said to be still of good value. 2,700 feet further west, a rich streak, probably dipping west, was worked to the depth of 200 feet on the Prince of Wales property; and, 1,100 feet still further west, the last pay-streak dipping east at an angle of 24°, was worked in connection with some other leads to the vertical depth of 110 feet and found very rich.

Veins south of anticline.

'A few veins have also been uncovered 4,400 feet east of Alpha Brook, immediately south of the anticline. At the western end of the district several veins have been uncovered on the south side of the anticline between the West Lake property and Coxcomb Lake, on blocks 1 and 12, but none have been worked. On what may be called the western extension of the district beyond Coxcomb Lake and west of the 1,085 foot fault described hereafter, Mr. August Michel, has exposed by trenching on the south side of the same anticline, some sixty-five lodes on blocks 11 and 12. He reports that these veins vary in width from one inch to two feet. One of them showed visible gold, and assays proved nineteen of the others to be auriferous, ten of which are considered as of exploitable value. All these auriferous veins are situated north of a band of coarse, quartzose sandstone, 380 feet wide, which is undoubtedly the continuation of that occurring south of the Nuggetty lead, and they are evidently intercalated between strata of the same horizon as those holding the South, Bunker and Nuggetty leads in the central part of the district. None of those veins have yet, however, been operated.

'In the process of the upheaval which has caused the great anti- Nova Scotia —*Cont.*
clinal fold, a bulge or broad transverse undulation has been formed on the south side of the dome, extending directly south some 3,000 feet from its centre. The outcrops of the strata on this undulation describe, at the surface, pronounced curvatures, and on either side they assume a comparatively straight course towards the east and west. A very important zone of numerous fissure-veins, has developed between the curved strata along this undulation, in the same manner as along the south-western undulation already described in the Renfrew district. One hundred and thirty distinct veins or belts of veins, have been uncovered or operated to a greater or less extent across the zone, giving a total of 172 feet of quartz or crushing ore, and all of them were surveyed.

'Proceeding from north to south on a line directly south from area 678, block 2, the most important and extensively worked veins are met with in the following order, at distances stated from the centre of the dome :— Auriferous veins of Mount Uniacke district.

Leads or Belts.	Thickness in inches.	Distance from centre of dome in inches.	Deepest works in feet.	Length opened in feet.	Remarks.
Twenty-foot..	240	100	Not worked		Holds mineralized streaks.
Eight-foot... .	96	210	Not worked		
Nichols	14	250	75	200	
Three-foot.....	34	275	Not worked		
Scotch Belt...	48	380	Not worked		Cut by cross-cut at 110 ft. level.
Number Three	10	400	260	400	Rich streak. At 110 ft. level, cross-cut
Cook.....	10-96	420	110	800	180 ft. south and 100 ft. north. At 150 ft. level, one 150 ft. south....
Cross Tunnel Belt	18	438	160	.....	
1st P. C. F. Slate Belt...	120	450	150	400	Belt 18 ft. wide; rich streak, 10 ft. ore, dips east, $< 25°$.
Murray. . ..	6	470	160	600	
Cut Lead Belt.	12	500	135	400	Rich streak on Cut lead.
2nd P. C. F. Slate Belt...	60	510	50	300	Belt 18 ft. wide, 5 leads, streak dips east.
.....	...	545	.....	....	Line between the C. P. F. and the
Logan.....	8	600	100	300	Montreal properties.
1st Montreal Slate Belt..	120	622	65	85	Belt 20 ft. wide; rich streak; 10 ft. ore; dips east.
2nd Montreal Slate Belt...	100	660	80	80	Belt 16 ft. wide; rich streak, 9 ft. ore dips east.
Contract.....	4	710	105	1,000	With other leads was also worked in open-cut, 25 ft. wide and 15 ft. deep.
. . ..	.....	875	.....	.....	From 710 to 875 ft. several leads, worked by shallow cuts.

Nova Scotia —*Cont.*

Leads or Belts.	Thickness in inches.	Distance from centre of dome in inches.	Deepest works in feet.	Length opened in feet.	Remarks.
South	3	875	65	1,500	This and the next two leads constitute the east-and-west zone.
Bunker	4	890	200	3,400	Worked to shallow depths for a great length.
Nuggetty	4	1,000	247	6,000	Four streaks worked, 150, 247, 200 and 110 ft. deep.
McPhail	4	1,070	140	600	Streak dips east.
Iron Slate Belt	72	1,115	40	400	Between 1,115 and 1,380 ft., band of coarse quartzite with several whin-bound veins of no value; no slate.
.....	.....	1,380	.....	.....	
Bain.	6-24	1,405	140	1,000	Affected by four faults at east end.
Allen Belt..	15	1,440	50	400	Two leads, 6 and 9 ins., in the belt.
....	....	1,870	.....	.....	Between 1,440 and 1,870 ft. coarse quartzite, several veins of no value, one only worked 45 ft.: no slate.
Howe Belt. ..	60	1,870	40	50	Belt 6 ft. wide, short streak dips east, 3 ft. ore.
Dimock Belt..	72	1,885	240	400	Belt gives 14 ft. ore on a rich streak (half crushing material) dipping east.
Robertson Belt	33	1,900	240	400	Belt of three leads, 3, 24 and and 6 ins. wide, on a rich streak dipping east and worked with the above belt for a length of 400 ft. from the surface.
.....	....	1,960	.....	.....	Between 1,900 and 1,960 ft., ten leads cut by cross-cut, averaging 12 ins.; not worked.
Hayes Belt...	36	2,155	80	100	Belt of three leads.
McQuarry Belt	60	2,175	40	150	Large belt.
Galena.. .. .	6	2,235	50	200	
N. McIntosh..	3	2,555	80	250	
Dowell Belt...	12	2,600	40	....	Belt of three leads.
S. McIntosh..	6	2,640	60	.....	
Dimock South Belt.	9	2,660	60	500	Belt of three leads.
Toronto	4	2,925	55	100	
Hayes Slate Belt	8	3,000	25	100	Workings furthest south.

Good prospects for deep mining.

'There is not the slightest doubt that most of the streaks of special enrichment have not been worked-out on the different veins, but extend down to much greater depth; and that, if some of them do run out, further systematic development by means of levels and cross-cuts will show that they are replaced by other parallel streaks of equal value, either in the same or in some adjacent vein. As the veins dip vertically and the pay-streaks are all situated on a line running north-and-south across them and pitch to the east at angles varying between 25° and 35°, the plane or zone containing these pay-streaks will also dip east at the same angle. As depth is attained, the form of the undulation may possibly change, and the extension of the zone will then change slightly in direction and dip, but it is most probable that it will extend beyond the limit of practicable mining. The large belts

of mineralized slate and quartz which have been operated on the P. C. F., the Montreal and the Phœnix properties, have been found to carry regular values on the north-and-south zone of special enrichment, and they still present a very promising field for extensive mining of low-grade ore. Nova Scotia —*Cont.*

'On the north side of the Mount Uniacke anticlinal fold, a few veins have been uncovered, but so far none of them have been worked, and that limb of the fold does not seem to offer a promising field, as the drift covering it has not been found auriferous.

'A great dislocation has affected the anticlinal fold at the west end of the district. It runs north-and-south through Coxcomb Lake, and gives to the anticlinal axis a left-hand displacement of some 1,085 feet at the head of the lake. This fault has already been mentioned as separating the main district from the large group of veins and belts of leads uncovered by Mr. A. Michel, but not yet worked. A series of five small left-hand and right-hand faults has also been made out, affecting the continuity of the Borden, Little, Nuggetty, West Lake and Polkinghorn leads on the Prince of Wales and West Lake properties, at the western end of the district. Two left-hand faults have disturbed the eastern end of the district in the vicinity of the Alpha Brook. The eastern one runs about S. 51° E. (mag.), crosses the Alpha Brook directly east of the Alpha lead and the main road 400 feet west of the Alpha Brook, and it gives a horizontal displacement of some 200 feet at the anticline. The other runs probably S. 27° E. (mag.), and gives a displacement of 40 feet on the Nuggetty lead, between two shafts 130 and 150 feet deep on the eastern pay-streak, worked on the P.C.F. property. Another line of disturbance, probably running north-and-south, occurs some 800 feet west of the south undulation and 300 feet west of the school-house, twisting the measures 80 feet to the north on its western side. Fault.

'In his "Ores of Nova Scotia" Dr. Gilpin states that mining began in this district in 1867, and during the next few years several companies were working; the returns, which rose in 1868 to 3,247 ounces, were maintained for twenty years at figures varying from 100 to 1,700 ounces. The total production of this district and that of South Uniacke from 1862 to Sept. 30, 1898, is given under the same head by the Department of Mines of the province, and it is 38,447 ounces, valued at $749,732, extracted from 54,325 tons; giving an average yield per ton of 2,000 lbs. of $13.80, which is certainly a very satisfactory result. Yield of gold.

'*South Uniacke Gold District.*—This district is situated on the Dominion Atlantic Railway and on the boundary line between Halifax South Uniacke.

Nova Scotia —*Cont.*

and Hants counties. Two weeks were devoted to a survey, with a view of making a large-scale plan of it, but the notes have not yet been plotted, and it would not be judicious to attempt a detailed description of its structure. The following general notes may, however, be given for the present.

'All the veins operated occur here also in slate layers interstratified between heavy beds of quartzite, on the north limb of an anticlinal fold, four miles to the south of the Mount Uniacke and Renfrew anticline.

'The measures on the south side of the anticline lie about horizontal for a distance of over a quarter of a mile, after which they begin to take another dip; while on the north limb, the angle at which they dip gradually increases, till it becomes vertical at a distance of 900 feet, giving to the axis-plane of the fold a dip to the south of about 45°. The fold has a westerly and easterly pitch, forming a very long elliptical dome.

Two veins worked.

'It may be said that only two veins of importance have so far been worked on this dome, the Hard lead and the Slate lead. A rich and wonderfully regular streak, dipping east at an angle of about 28° has been worked on the Hard lead for a total length of some 1,800 feet on that incline, crossing three properties; and it has given the remarkable average yield of ten to twelve ounces to the ton. The Slate lead, lying a short distance to the south of the latter, has also been worked extensively, and was still being operated at the time of our visit.

'These leads are situated at a distance of some 900 feet to the north of the anticline, where the strata begin to assume a vertical and constant dip, after having gradually increased from 0° to 90°, or, in other words, at the limit of the curvature of the truncated fold. This limit constitutes then a narrow zone of special enrichment, which intersects the strata and veins intercalated at a very slight angle, keeping a course more to the north towards the east, and more to the south towards the west. On the leads occurring north of the Hard lead, prospecting should therefore be prosecuted further and further towards the east receding from that lead, and on the leads south of the Slate lead receding further west receding from that lead. In depth the pay-zone dips to the south, like the axis of the fold, at an angle of about 45°.

Other gold Mining districts.

'Besides the above three gold-mining districts actually surveyed last summer, a few other less important mining developments have been examined in the region. The surveys of these have not yet been all plotted, but a few preliminary notes may here be given.

'*Upper Newport Gold District* (McKay Settlement, Ashdale or Meander River).—Five miles north of the Mount Uniacke anticline, the quartzite division of the gold-bearing series is overlain conformably by a great belt of slate of the upper division. The latter, at Upper Newport, is covered on its northern limit by the gypsum, limestone and sandstone of the Windsor series of the Carboniferous. It constitutes the high ridge of the Rawdon and Ardoise hills, and stretches to the south-west to within one mile of Ponhook Lake, on the St. Croix River, where it is cut by granite. The measures of this belt have been plicated into one main synclinal fold, followed to the north by a main anticlinal fold.

Nova Scotia —*Cont.*

Upper Newport gold district.

'The anticline, which is the most northern one met with to the east of Windsor, runs N. 63° E. (mag.) and follows the escarpment marking the northern limit of the Rawdon and Ardoise hills, but to the east of Herbert River and to the west of Martin Brook, it is covered over by the Carboniferous rocks, which limit its total length to six miles. It crosses the Little Meander River at the McKay settlement bridge, the Meander River three-quarters of a mile above its junction with the latter branch, and the Herbert River at the Rawdon road bridge. These streams cut through deep gorges, affording good sections, but elsewhere rock-exposures are seldom met with, as the surface is covered with heavy drift.

Meander River.

'The form of this upheaval is that of a flat, broad fold, the limbs of which dip north at an angle of 15° immediately north of the axis, and south at an angle increasing from 10° to 35°. It pitches to the east between the Little Meander River and its eastern extremity on the Herbert River; but, at a distance of about one mile west of the former river, the fold appears to pitch westward, thus forming a very broad dome, the centre of which is situated at a short distance to the west of that stream.

Form of the anticline.

'Several veins have been prospected on the eastern dip of this dome, most of the work being done along the deep gorge of the Little Meander River, below the bridge, where many veins follow the plane of stratification of low-dipping, bluish-black, pyritous slates with occasional bands of black, hard, fine-grained quartzites; and more especially at a point some 500 feet below the bridge, where the strata curve and form an undulation dipping apparently to the north-east. These mining operations are generally called the McKay settlement gold mine.

'A few small veins running north-and-south across the stratification and dipping east at an angle of 85°, have been prospected, by John Withrow and others, on this dome, at a distance of about half a

Cross veins

Nova Scotia —*Cont.*

mile west of the Little Meander River, about the same distance south of the McKay settlement road. The deepest shaft on these veins, however, does not reach over 50 feet.

Alluvial deposits.

'*Meander River Alluvial Gold Deposits.*—About 1,500 feet below the bridge on the Little Meander River, the deep and rocky gorge is succeeded by the flat intervale of Meander River, into which flows, some 1,500 feet further, the former stream. The auriferous *débris* washed down by the Little Meander River from the above-described anticlinal fold as well as from the Ardoise gold district, at the head-waters of the same stream and described in the sequel, has been deposited on this flat form in the alluvial deposits, which have lately been worked on a small scale. At the time of my visit, two men were making good wages, I was told, by washing coarse gold from the present bed of this river, some 1,500 feet below the bridge.

'The alluvial deposits of gold extend also below the forks of the two rivers, and numerous prospecting trenches were made across the intervale early last summer, for a mile and a-half down the river, through the gravel and sand to the bed-rock, to ascertain the possibility of their being worked extensively. The results of this operation have not been made public, as far as I know, but it is very probable that some parts of the old river-beds may prove sufficiently rich to be worked with profit.

Ardoise gold district.

'*Ardoise Gold District.*—This is situated on the head-waters of the Little Meander River in Hants county, directly east of Ellershouse station on the Dominion Atlantic Railway, a distance of five and a-half miles by a wagon road. Several veins have been uncovered, a few of which were worked to a limited extent, some years ago. They follow the lines of stratification of a wide band of pyritous, bluish-black, graphitic slate running N. 65° E. (mag.) and dipping south at an angle of 80°. This band forms part of the great slate belt of the Rawdon and Ardoise Hills, above described, and is situated some 2,500 feet above the base of the slate division of the gold-bearing series. The veins occurring here are not the result of an anticlinal upheaval, but have been produced on a broad curvature of the strata with the convexity facing toward the south. The zone affected by this curvature extends some distance north-and-south across the strata and much resembles in its general features the important south zone of the Mount Uniacke district just described. One particularly large belt of auriferous slate, holding veinlets of quartz, has lately been prospected here, and a series of assays conducted by Mr. F. H. Mason, Halifax, has given such satisfactory results as to warrant its being operated.

'*Dufferin Mine, Salmon River Gold District.*—I took occasion last fall, at the close of field operations, to revisit the Dufferin mine, in the gold district of Salmon River, Halifax county, being anxious to learn the result of recent extensive development there, because of its bearing on improved methods of mining in the province generally. This district was surveyed in 1897, and a plan and section on the scale of 250 feet to one inch were published the following year. As stated in the description given at page 110 of the Summary Report for 1897, the surface is so largely covered with drift that only a few outcrops could be observed; moreover, mining operations were at the time suspended, the mine was full of water, and the only other data available to make out the geological structure were those given by the company's plans and sections of the underground workings, which, while giving the general structure of the main workings, made no attempt to unravel the important structure of the measures beyond them, along the cross-cuts towards the north and south.

Nova Scotia —*Cont.*
Halifax county.
Dufferin mine.

'Subsequently, this property was acquired by the Montreal–London Gold and Silver Development Company, re-opened and provided with a thoroughly good mining plant and a modern 60-stamp mill with 23 Frue vanners of a capacity of 240 tons per 24 hours. The important systematic developments made by this company afford an excellent opportunity for studying the structure of the anticlinal fold below the surface, and I have to thank the officers of the company for permission to make such an examination, and Mr. E. A. Daly, the manager, for providing me with every facility and assistance.

'Only a general examination was made of the extensive mining operations carried on by the first company since the discovery in 1880, but a detailed survey was made of the cross-cuts and drifts along the veins at the 134, 200 and 300 feet levels. These surveys were plotted and a transverse section through the vertical shaft has been compiled. This section shows that the form of the anticlinal fold passing through the district differs from that given in the published plan, in that, instead of a single fold, there occur two minor anticlinal flexures along the crest of the main plication.

Two anticlines.

'The southern fold, the sharpest of the two, is that on which occurs the system of large superimposed saddle-veins which have been so successfully worked to a depth of over 300 feet. The northern fold, has its apex at a distance of 245 feet to the north of the first, and is much broader. Its southern limb dips south at an angle averaging 45°, and is apparently not favourable to the formation of quartz, as the 200 feet of cross-cut made at the 200-foot level, between the syncline at the vertical shaft and its apex, gave only one vein, one inch in thickness.

Nova Scotia —*Cont.*

The north limb dips to the north at an angle gradually increasing up to 78°, and does not show quartz in the forty-five feet completing the total length of the above mentioned cross-cut to the north. Quartz veins, said to be auriferous, have, however, been uncovered at the surface, at a distance of 105 feet and more to the north of its apex, and these may be worth developing. These veins form a zone extending in depth probably parallel to the axis-plane of the fold and dipping south at an angle of 78°. This inclination corresponds nearly to that of the axis-plane of the southern anticlinal fold, and as the two systems of quartz veins are 300 feet distant from one another, they could not advantageously be worked together.

'Two important and distinct water-powers are situated on the Salmon River, at a distance of three-quarters of a mile to the west and south of the vertical shaft. One of these only is utilized to a limited extent, but if the best possible advantage were taken of the united capacity of both of them, they would be a great source of economy in fuel.

Workings at the Dufferin mine.

'As already stated, all the saddle-veins worked at the Dufferin mine are situated along the apex of the southern anticlinal fold. They follow the planes of stratification and nearly always occur in bands of slate. At the surface, the fold dips south at an angle of 62°, and north at an angle of about 77°, and curves abruptly at the apex which crops out fifteen feet south of the vertical shaft. It pitches eastward and westward at very low angles, forming a long narrow elliptical dome, with its centre not far to the west of the vertical shaft. The axis-plane of the fold dips south at an angle of 77°, being 48 feet distant from the vertical shaft at the cross-cut from the 200-foot level, and 72 feet at the 300-foot level, receding 24 feet to the south of the vertical for every 100 feet of depth.

Limit of the veins

'The axis-plane of the synclinal trough dividing the two anticlinal folds runs parallel with those of the latter and lies 48 feet to the north of that of the southern one. One of the most important conclusions derived from the study of these folds is that the axis plane of the syncline forms the northern and deepest limit of the north-dipping veins along the south fold. The north lead operated by the first company was worked 120 feet in depth, to the bottom of the synclinal trough, where it naturally ended, but was thought by those operating it to be cut off by a fault. At the 200-foot level cross-cut, where the synclinal axis-plane is exactly at the south side of the vertical shaft, a north-dipping vein following a band of slate comes to an end at a point where the strata abruptly curves up under the syncline. In like manner, at the 300-foot level cross-cut, a vein, eight inches in thick-

ness, was observed to pinch out at the syncline, 24 feet south of the vertical shaft. The inclination of the northern limit of the formation of quartz will thus have to be taken into consideration in extending the mining developments to greater depths, for it will probably recede an additional 24 feet to the south of the vertical shaft for every 100 feet sunk below the 200-foot level, so that at a depth of 1,000 feet 192 feet of cross-cutting to the south will have to be done to reach it. Nova Scotia —*Cont.*

'Along the cross-cut, at the 200-foot level, the width of the quartz formation extends from the syncline, at the vertical shaft, for 177 feet towards the south, or 129 feet beyond the anticline, and no quartz was found along the remaining 194 feet of cross-cut. At the 300-feet level the cross-cut extending 254 feet to the south of the syncline, exhibited quartz veins along its whole length.

'As far as mining operations have gone, they prove that the largest and richest bodies of quartz are chiefly confined to the apex of the fold, especially for the first 200 feet in depth. At the 300-foot level the zone of larger and richer veins appears to be less confined to the crest of the fold and to extend to a greater distance to the south. This is due undoubtedly to the fact that the fold gets a little broader at this level. Should this spreading of the fold continue in depth, the zone of enlargement and special enrichment of the veins will probably gradually recede from the anticline towards the south, and will consequently be at a still greater distance from the vertical shaft. However, experience gained at Bendigo, Australia, where similar saddle-veins have been worked to depths of over 3,000 feet, proves that the form of the fold is not always constant but alternately broader and sharper, giving a succession of large saddle-reefs of variable value. In like manner, a succession of large saddle-veins and legs may be met with at the Dufferin mine to a great depth, portions of which will be sufficiently rich to be worked with profit. Richest quartz at the apex.

'All that has been said, so far, refers to the transverse section made at the vertical shaft. If we consider now the main fold on its eastern and western extension, we find that the southern plication is in the form of a long narrow elliptical dome, pitching, from a point not far west of the vertical shaft, towards the east and west at very low angles, gradually increasing to nearly 18°. The first company operated the North and South leads along the western pitch of the fold, for a length of 1,211 feet, and 577 feet towards the east, giving a total development of 1,788 feet along the first saddle-back reef, the stoped portion having an average depth of 120 feet and a maximum depth of 300 feet. At the eastern and western extremities Main fold, east and west.

Nova Scotia —*Cont.*

of these workings, the saddle-veins still kept a good average width and richness, and they may probably be found remunerative for several thousands of feet further east and west.

'Towards the west the bed-rock is heavily covered with glacial drift and no prospecting has been attempted in that direction. Towards the east a little prospecting has been done 1,200 feet east of the vertical shaft, uncovering three large promising veins on the south dip, immediately south of a prominent ridge of "whin" forming the apex of the southern fold; and, as the cover is of little thickness, more development should be done in that direction.

Fault.

'The left-hand fault shown on the published plan of the district, as running north and south at a distance of 850 feet east of the vertical shaft, could not be proved with certainty, but its horizontal displacement is probably not over 50 feet.

Lake Eagle.

'Several large veins have also been uncovered on the south dip at a distance of 3,600 feet east of the vertical shaft, on what was formerly known as the Lake Eagle property, two of which have been worked to a depth of 50 feet. The Montreal-London Company have lately acquired this ground and a vertical shaft is being sunk to develop it. The first vein cut is large and promising and there is reason to believe that the shaft as located will afford the means of working a zone of large payable veins. It must be kept in mind, however, that the zone dips south at an angle probably near 77°, and, as depth is attained, cross-cutting south will have to be made to reach it. This zone is the continuation towards the east of that of the Dufferin, and it goes to show that its whole length, 3,900 feet, from the vertical shaft to the Lake Eagle, is probably worth developing.

Large fault.

'The rock exposures north of the Lake Eagle vertical shaft, apparently indicate a double-folding—the eastern prolongation of that of the Dufferin mine. A left-hand fault passes probably through Lake Eagle in a south-eastern direction, giving a horizontal displacement of some 1,500 feet.

General conclusions.

'From the above description of the structure of the district, it will appear that the southern plication of the main anticlinal fold presents a system of large superimposed parallel saddle-veins, extending over one mile and a half in length and probably to a great depth; that large portions of these veins, already operated along a well-defined zone, have proved highly remunerative for a length of 1,788 and a depth of 300 feet, and that they may be found remunerative for a length of probably over a mile and to a great depth, if the developments are judiciously conducted. Every effort should, therefore, be

made to determine the payable portions of the veins by a careful system of testing along the development workings. In this connection I would strongly recommend mill-tests and would advise that, whenever practicable, the twelve batteries should be fed separately with ore extracted from the different veins of portions of veins. In this way, the exact values of the blocks of veins stoped will be obtained, and, if properly recorded, will show the distribution of gold throughout the veins and be of great assistance in defining the form and direction of the zone of pay-shoots and in laying out future operations. If some such system of value-plans were kept by mine managers, there is no doubt that more extensive permanent mining would be done in Nova Scotia, and many of the now abandoned mines would be found remunerative. Nova Scotia —*Cont.*

'The following are the official returns received at the Department of Mines from the Dufferin mine, from 1881 to the last year of operation of the first company in 1895 :— Yield of gold.

Year.	Tons.	Ounces.
1881	1,640	1,785
1882	3,460	4,315
1883	7,602	3,885
1884	9,799	3,397
1885	10,880	4,924
1886	11,628	6,509
1887	10,602	3,258
1888	9,925	3,354
1889	7,633	2,032
1890	6,415	2,070
1891	5,210	1,406
1892	4,220	1,042
1893	3,220	882
1894		
1895	1,467	271
	93,701	39,130

'These figures give an average yield of 8 dwts. $8\frac{1}{5}$ grs. per ton.'

Dr. G. F. Matthew, of St. John, New Brunswick, at my suggestion, has undertaken to make an examination of the Cambrian and other old rocks of Cape Breton Island, with the special purpose of fixing their exact relations and collecting and describing the fossils contained in them. In pursuance of this object he spent about six weeks in the field last summer and is at present devoting his spare time to the study of the specimens. The following is his general account of the work done. He has already prepared and published a preliminary account Work of Dr. G. F. Matthew in Cape Breton.

Nova Scotia —*Cont.*

of some of the fossils obtained in the December number of the Bulletin of the Natural History Society of New Brunswick.

On arriving in Cape Breton, Dr. Matthew first turned his attention to the structure of the rocks that have there been referred to the Cambrian system. He writes :—

The Cambrian rocks.

'The Cambrian (proper) and the Etcheminian which underlies it, are contained in several narrow synclines between St. Andrew Channel and the East Bay of the Bras d'Or Lake and in the broad valley of the Mira River. These formations (terranes) in the narrow valleys generally present monoclinal folds, but in the Mira basin several synclines are developed. The folds usually have high dips on the east side, or are there faulted against the older rocks, felsites and syenites.

'Though both here and in the New Brunswick region the synclines in the Cambrian rocks run north-east and south-west, it will be noticed that in New Brunswick the high dips, overturns and faulted contacts are prevailingly on the north-west side of the folds, whereas in Cape Breton they are generally on the south-east side.

Upper Cambrian fossils.

'Only Upper Cambrian faunas were found in the Cambrian of this region, those of the Lower Cambrian, i.e. *Paradoxides* and *Protolenus*, present at St. John, being apparently absent here.

'The Cambrian rocks of Cape Breton show two principal divisions —a lower, consisting chiefly of flag-stones and sandy slates—and an upper in which fine dark-gray slates prevail. A pure gray colour, sometimes reaching the intensity of black, characterizes all the true Cambrian rocks of Cape Breton except the basal conglomerates, which are sometimes locally coloured by the abounding débris of the immediately underlying rocks.

Effect on topography.

'The difference in texture and cohesion of the rocks of the two divisions of the Cambrian in Cape Breton has affected the topography of the region, for the important streams of the Cambrian areas almost everywhere run over the rocks of the upper division which have been eroded to form valleys and thus give passage to these streams.

'On the contrary, the coarser and harder beds of the lower division, are usually to be found on the ridges between the streams. Such an anticlinal form is the "Big Ridge" in Mira valley. Some hematite beds occur with the Cambrian flagstones on this ridge, which have been deposited under conditions similar to those of the Cambrian hematites of Bell Island in Newfoundland. The Cape Breton beds that have been found, however, are thin. At the southern end of this ridge the surface deposits seem to be liberally charged with iron, which gives an ochreous colour to the soil and glacial *débris*.

'The underlying Etcheminian terrane is contrasted with the Cambrian by its red and greenish-gray tints. It also exhibits two sets of strata of unlike aspect—a lower mostly of red conglomerates and sandstones with effusive volcanic rocks in some districts; and an upper consisting of greenish-gray shales or slates with some usually thin conglomerate bands. These slates are the "argillites" of Mr. Fletcher's reports. The Etcheminian is generally, but not always present beneath the Cambrian, and conforms to it in structure. Nova Scotia —*Cont.* Etcheminian rocks.

'The palæontology of these two terranes is interesting. In the Etcheminian a new fauna was found, consisting so far as observed, of seven species of brachiopods and five of ostracods. The fossils of both these groups show a general resemblance to those of the *Protolenus* zone (Lower Cambrian) in New Brunswick. *All* the genera of this fauna are present in the *Protolenus* beds, but *none* of the species. Their fauna.

'In the Cambrian a fauna occurs just above the basal conglomerate, which, from the species present, would appear to be Upper Cambrian. Above this come strata which by the fossils, burrows and tracks, compare with Band *C* of Division 2 of the St. John group, which is Upper Cambrian. Passing to the upper division of the Cape Breton Cambrian, we find the *Peltura* fauna well developed at several localities, and the *Dictyonema* fauna at one. The full range of the Upper Cambrian faunas as represented in the St. John group is therefore likely to be present in Cape Breton. Fauna of the Cambrian.

'It is therefore important to have an understanding of the structure of the Cambrian system in this island and to find it conform so closely to that of the New Brunswick areas, allowing for the absence of the Lower Cambrian, (*Paradoxides* and *Protolenus* beds).'

CHEMISTRY AND MINERALOGY.

Reporting on the work done in these branches of the Survey's operations, Dr. Hoffmann says:—'The work carried out in the chemical laboratory during the past year, has been conducted upon the same lines as those heretofore followed, that is to say, it has been chiefly confined to the examination and analysis of such minerals, and ores, as were considered likely to prove of economic value and importance. Briefly stated, the ground covered, included:— Dr. Hoffmann's report. Chemistry and mineralogy.

'1. Analyses of fuels, namely of lignites, lignitic coals, and coals.

'2. Analyses of spring-, lake-, and river-waters from localities in the provinces of Nova Scotia, New Brunswick, Quebec and Ontario, the North-west Territory, and the province of British Columbia.

Chemistry and mineralogy—*Cont.*

Examinations made.

'3. Analyses of limestones and dolomites from certain parts of the provinces of Nova Scotia, New Brunswick and Ontario, and the North-west Territory. A continuation of the series of analyses of such stones already carried out in connection with an inquiry into their individual merits for structural purposes, suitability for the manufacture of lime or of hydraulical cement, or employment for metallurgical and other uses.

'4. Analyses of iron ores from various localities in the province of Nova Scotia.

'5. Analyses, partial, of nickeliferous pyrrhotites from the provinces of Quebec and British Columbia.

'6. Assays of a large number of ores for gold and silver from various localities in the provinces of Nova Scotia, New Brunswick, Quebec, Ontario and British Columbia, as likewise from certain parts of the North-east and North-west Territories.

'7. Analyses of rock specimens from the province of British Columbia.

'8. Analyses of several interesting, and, from a commercial standpoint, important minerals, some of which had not previously been recognized as occurring in Canada, as for instance:—1. Hübnerite, a tungstate of manganese, which was found, in some quantity, at Emerald, Inverness county, in the province of Nova Scotia. 2. Natron, a hydrous sodium carbonate, which has been found in a series of small shallow lakes lying not very far north of Clinton, Lillooet district, in the province of British Columbia. In one of these lakes, Lake Good-enough, that from which the material examined was taken, the deposit was found to cover the entire bottom of the lake and to be of considerable thickness, and to represent, as near as could be estimated, some twenty thousand tons of carbonate of soda. In addition to an analysis of the natron, a complete analysis has been made of the water of the lake, as likewise of the mud covering the bottom of the lake and upon which the natron rests. 3. Hydromagnesite, a basic magnesium carbonate, which has been found in considerable abundance in the vicinity of the 108-mile House on the Cariboo road, Lillooet district, and more recently by Mr. J. C. Gwillim, at the back of Atlin town-site, on the east side of Atlin Lake, in the province of British Columbia.

Natron.

Hydromagnesite.

9. 'An analysis has also been made of the celestite (strontium sulphate), from the township of Bagot, Renfrew county, province of Ontario, and an examination has likewise been entered upon of a mineral, evidently spodumene, collected by Mr. A. P. Low, from Walrus Island, east coast of James Bay, Ungava district.

10. 'Miscellaneous examinations, such as the partial analysis or testing, as the case might be, of brick and pottery clays, shell-marls, graphitic shales, iron-sands, and other material not mentioned under the above headings. Chemistry and mineralogy—*Cont.*

'The detailed results of the foregoing work, are given in my annual report, the manuscript of which has been prepared, and is now in the hands of the printers.

'The number of mineral specimens received during the period in question, for identification, examination or analysis, amounted to one thousand and seventeen. Many of these were brought by visitors, and the information sought in regard to them was in most cases communicated to them at the time of their calling. In other instances, however, those where a partial or complete analysis was considered desirable, as also in the case of specimens which had been sent from a distance, the results were communicated by letter. The number of letters personally written, chiefly in this connection, and generally of the nature of reports, amounted to two hundred and eighty-three, and of those received, to one hundred and thirty-five. Specimens identified.

'Messrs. R. A. A. Johnston and F. G. Wait, assistants in the laboratory, have both, as a result of their unremitting assiduity accomplished a very large amount of work. The former has carried out a very large number of gold and silver assays, made many important mineral analyses, and, in addition, conducted a great variety of miscellaneous examinations, whilst the latter has made numerous water analyses, some mineral analyses, many partial analyses, and has also carried out some miscellaneous examinations. Minerals examined

'In the work connected with the mineralogical section of the museum I have, as heretofore, been diligently assisted by Mr. R. L. Broadbent.. He has been steadily engaged in the permanent labelling and cataloguing of specimens, a work which must of necessity be of a more or less continuous character by reason of the constant additions to the collection, the re-adjustment of certain cases to allow of the introduction of additional specimens, and a variety of other work in connection with the mineralogical and lithological collections. Work of assistants.

'The additions to this section of the museum during the past year comprised, one hundred and eighty-one mineral specimens, one hundred and fifty rock specimens, with microscopic sections of the same from the Nipissing and Temiscaming regions, collected by Mr. A. E. Barlow, and three hundred and sixty-four rock specimens Contributions to museum.

Contributions to museum —*Cont.*

from the Ungava district, collected by Mr. A. P. Low. Of the additions to the mineralogical collection, the following were :—

(*A.*) Collected by members of the staff engaged in field work in connection with the Survey :—

Ami, Dr. H. M.:—

a. Copper-pyrites, iron-pyrites, and spathic iron, from Polson Lake, Antigonish county, N.S.

b. Gypsum (var. selenite), from a quarter of a mile from Grand Lake, Douglas township, Hants county, N. S.

c. Hæmatite, from Grand Pré, Kings county, N. S.

d. Native copper, from Cape d'Or, Cumberland county, N. S.

e. Barite, from six miles north of Brookfield, Colchester county, N. S.

f. Analcite, from McKay Head, above Parrsborough Harbour, Cumberland county, N. S.

g. Amygdaloidal trap, from River Avon shore, Horton Beach, Bay of Fundy, Kings county, N. S.

h. Oil shale showing effects of weathering, from the Albert mines, Albert county, N. B.

i. Honey-combed limestone, from the nine-fathom reef, seventy miles south of Burnt Island, Lake Huron, O.

Barlow, A. E.—

a. Biotite, from the township of Cardiff, Hastings county, O.

b. Magnetite (large crystals), from the township of Faraday, Hastings county, O.

c. Corundum (blue), from the township of Dungannon, Hastings county, O.

d. Pyrrhotite, from the township of Dungannon, Hastings county, O.

e. Pyroxene and orthoclase (crystals), from the township of Herschell, Hastings county, O.

Brock, R. W.—

a. Jamesonite, from D. Whitley's (Red Paddy's) claim, head of Kettle River, Yale district, B.C.

b. Gmelinite, from the War Eagle mine, Rossland, West Kootenay district, B.C.

Gwillim, J. C.—

a. Magnesite rock, from about one mile north of Pike River, Cassiar district, B.C.

b. Hydromagnesite, from Atlin, Cassiar district, B. C.

c. Volcanic ash, from Fourth of July Creek, Atlin, Cassiar district, B.C.

Contributions to museum —*Cont.*

Low, A. P.—

a. Epidote, 35 specimens, from Walrus Island, Paint Hills, east coast of James Bay, Ungava district, N.E.T.

b. Spodumene (?) 14 specimens, from Walrus Island, Paint Hills, east coast of James Bay, Ungava district, N.E.T.

c. Molybdenite, 15 specimens, from island No. 12, Paint Hills, east coast of James Bay, Ungava district, N.E.T.

d. Amazon stone, 7 specimens, from islands at Paint Hills, east coast of James Bay, Ungava district, N.E.T.

e. Garnet, from Cape Hope, east coast of James Bay, Ungava district, N.E.T.

f. Axinite, 30 specimens, from Manitounuck Sound, east coast of Hudson Bay, Ungava district, N.E.T.

g. Magnetite and hematite, 5 specimens, from Nastapoka Islands, east coast of Hudson Bay, Ungava district, N.E.T.

h. Anthraxolite, from Long Island, south of Great Whale River, east coast of Hudson Bay, Ungava district, N.E.T.

McEvoy, James :—

a. Altaite, from Pay Roll mine, Nigger Creek, twelve miles S.W. of Cranbrook, East Kootenay district, B.C.

b. Silt from near the foot of the glacier, at Glacier, C.P.R., B.C.

(*B.*) Received as presentations :—

Albert Manufacturing Company, Hillsborough, N.B. :—

Gypsum with albertite, from Hillsborough, Albert county, N.B.

Blue, John, Eustis, Q. :—

Vivianite, from lot 25, range II of Hatley, Stanstead county, Q.

Brehlich, H., Nelson, B.C. :—

Chalcocite, from the Grey Eagle claim, near Meadow Creek, Kamloops, Yale district, B.C.:—

Cameron, J. J.

Tourmaline, from the Stormont gold district, Guysborough county, N.S.

Carter, J. J., Manilla, O., per Dr. H. M. Ami, (Survey) :—

a. Calcareous tufa, from the township of Brock, Ontario county, O.

b. Shell marl, from the township of Somerville, Victoria county, O.

De Wolf, Geo., Vancouver, B.C.:—

Limonite, from the Lardeau district, B.C.

Fossil Flour Company, Bass River, N.S., D. S. Collins, Manager :—

Infusorial earth (tripolite), from Bass River, Five Islands, Colchester county, N.S.

Contributions to museum —*Cont.*

Fraser, J. D., Springville, N.S., per Dr. H. M. Ami (Survey) :—
Limestone, from Springville, Pictou county, N.S., used as a flux by the Nova Scotia Steel Company, New Glasgow, N.S.

Genest, P. M. A., Department of Crown Lands, Quebec :—
Model of a gold nugget from the Gilbert River, Beauce county, Q.

Hallwright, Dr. F. W. :—
Copper-pyrites, from Great Slave Lake and Buffalo River, N.W.T.

Hille, F., Port Arthur, O., per W. McInnes (Survey) :—
Amethystine quartz with crystals of green fluorite, from the Porcupine (Twin Cities) mine, township of Gillies, district of Thunder Bay, O.

Hunter, Mrs. H., Granite Creek, B.C. :—
Limestone concretion, from Granite Creek, Yale district, B.C.

Jones, L. G., Morden, Manitoba :—
Nodule of iron-pyrites, from Morden, Manitoba.

Klock, R. A., Klocks Mills, O.
Copper-pyrites, iron-pyrites, galena and zinc blende, from Matta wabika River, Montreal River, district of Nipissing, O.

Macfarlane, Thomas, Ottawa, O., per Dr. R. W. Ells (Survey) :—
Moss litter, from Welland county, O.:—

McAlister, John, M.P, Campbellton, N.B.:—
Native copper, from Scaumenac River, Bonaventure county, Q.

Markham, Alfred, St. John, N.B.:—
Mountain cork, from west side of harbour, near village of Lower Five Islands, Colchester county, N.S.

Obalski, J., M.E., Inspector of Mines, Quebec :—
a. Clay, from lot 45, range IV. (on Petite Paquette River), township of Macpès, Rimouski county, Q.
b. Marl, from Lac à la Peinture, township of Neigette, Rimouski county, Q.

Parsons, J. A., Halifax, N.S., per Dr. H. M. Ami (Survey) :—
Sand from Sable Island, off the east coast of Nova Scotia.

Poirier, Senator, Shediac, N.B. :—
Bog iron-ore, from Rogerville, Northumberland county, N.B.

Queen City Oil Company, per E. A. Olver, Ottawa, O.:—
Sample of Canadian coal oil (Photogene).

Ritchie, R. McG., Bryson, Q.:—
Pyrrhotite, from lot 5, range II. of Calumet Island, Pontiac county, Q.

Contributions to museum —*Cont.*

Robillard, Henry, Ottawa, O.:—
Limestone, from lot 22, con. I. (Ottawa front), township of Gloucester, Carleton county, O.

Roger, C. J., Ottawa, O., per Dr. H. M. Ami (Survey) :—
Sandstone, from South March, Carleton county, O.

Rudderham, D.:—
Infusorial earth from Cape Breton county, N.S.

Rutledge, J., Ottawa :—
Mica (phlogopite), from lot 2, range V. of Masham, Ottawa county, Q.

Ryan, A.:—
Limestone concretions, from Les Erables, Ottawa River, township of Mattawan, district of Nipissing, O.

Soues, F., Clinton, B.C.:—
Auriferous quartz, from McGillivray Creek, Anderson Creek, Lillooet district, B.C.

Sutherland, Hugh, Winnipeg, Man.:—
Silver ore, from California mine, Nelson mining district, West Kootenay, B.C.

Thompson, R. M., President Orford Copper Company, 99 John Street, New York :—

Samples of nickel refinery products :—
a. First matte.
b. Concentrated matte.
c. Copper tops.
d. Nickel bottoms.
e. Copper matte from '*c.*'
f. Blister copper from '*e.*'
g. Finished nickel oxide.
h. Finished nickel.

Thomson, H. C., 3 Park Square West, Regents Park, London, N.W., England :—
Titanic iron ore, from Rapid River, Bay of Seven Islands, Saguenay county, Q.

Wallingford, E., Templeton, Q., per C. W. Willimott (Survey) :—
Concretionary nodule, from the Blanche River, Templeton, Ottawa county, Q.

Weston, T. C., Ottawa :—
Fossiliferous limestone, from Mountain Hill Cliff, Quebec city, Q.

Contributions to museum —*Cont.*

Willimott, C. W., Ottawa

Crystals of sphene, from the township of Litchfield, Pontiac county, Q.

Yeo, C. T., Ottawa Normal School, per Dr. H. M. Ami (Survey):—

Calcareous tufa, from the north-east corner of the township of Scarborough, York county, O.

Collections presented to educational institutions.

'Mr. C. W. Willimott was, during the first three months of the year, for the most part engaged in making up collections of minerals and rocks for various Canadian educational institutions. The following is a list of those to which such collections have been sent:—

1.	Armstrong Corners School, Gasperaux Station, N.B.	75 Sps.
2.	No. 5 Demoiselle Creek School, Hillsborough, N.B.	75 "
3.	High School, Port Hawkesbury, C.B	100 "
4.	St. Andrews School, Annapolis Royal, N.S.	100 "
5.	Public School, Tatamagouche, N.B	75 "
6.	High School, South Edmonton, N.W.T.	100 "
7.	St. Dunstans Convent, Fredericton, N.B	75 "
8.	North Head Superior School, Grand Manan, N.B.	100 "
9.	High School, Westport, Digby, N.S.	100 "
10.	High School, Port Dover, Ont.	100 "
11.	Public School, Pleasantvale, Albert Co., N.B.	75 "
12.	Prince of Wales College, Charlottetown, P.E.I	100 "
13.	High School, Blackville, N.B.	100 "
14.	Model School, Freligsburg, Que.	75 "
15.	Shawville Academy, Shawville, Que.	75 "
16.	Free Library, Vancouver, B.C.	100 "
17.	St. Margaret College, Toronto, Ont.	100 "
18.	Lennoxville Academy, Lennoxville Que.	75 "
19.	St. Peter's Convent, St. John, North End. N.B.	75 "
20.	No. 4 School, Meductic, York Co., N.B.	75 "
21.	Public School, Wallace, N.S.	75 "
22.	Trafalgar Institute, Montreal, Que.	75 "
23.	No. 5 School, Rothesay, Nauwigewauk, N.B.	75 "
24.	Selma School, Selma, N.B.	75 "
25.	High School, Victoria, B.C.	25 "
26.	St. Anne's Convent, Glace Bay, C.B., N.S.	75 "
27.	Lourdes Convent, Lourdes, Pictou, N.S.	75 "
28.	Public School, Pisarinco, N.B.	75 "
29.	Superior School, Dalhousie, N.B.	25 "
30.	High School, Leamington, O.	100 "
31.	Havre de Boucher School, Antigonish, N.S.	75 "
32.	Aberdeen High School, Moncton, N.B.	100 "
33.	Central High School, Hamilton, Ont.	100 "
34.	Victoria Museum, Peterborough, Ont.	100 "
35.	County Academy, Antigonish, N.S.	100 "
36.	Notre Dame Convent, Newcastle, N.B.	75 "
37.	Granby Academy, Granby, Que	100 "

'In addition to which, the following persons have been supplied:—

D. W. Macdonald, Edmonton, N.W.T., with 25 specimens, in exchange.

Col. A. W. Roebling, Trenton, N.Y., U.S., with 1 specimen.

Consul General for Belgium, Ottawa, with 5 specimens.

Collections presented to educational institutions —*Cont.*

E. H. Matthews, York Town, South Australia, with 25 specimens in exchange.

J. D. Fraser, Ferrona, Nova Scotia, with 75 specimens in exchange.

'Making a total of three thousand two hundred and six specimens thus distributed.

'From the commencement of April to the close of the year, Mr. Willimott was principally occupied in connection with the collection, reception and despatch of the specimens from various parts of Canada intended for the forthcoming exhibition in Paris. In this work he visited Montreal, Richmond, Sherbrooke, Dudswell, Black Lake and Quebec city, all in the province of Quebec. At a later date he proceeded to Halifax, to secure uniformity in regard to the collections from Nova Scotia, brought together there by the provincial Department of Mines and Works.'

Work for Paris Exhibition.

MINERAL STATISTICS AND MINES.

Of the work of this section, Mr. E. D. Ingall, reports as follows:—

Statistics and Mines.

'The section has throughout the year performed its regular function of collecting and recording information regarding the mineral resources of the country, not only for the purpose of issuing the annual report, but in order to have on record as complete information as possible relating to the various mineral deposits of commercial importance and to their development.

'Besides the information of a technical and statistical nature made public through the annual reports, much has been done, as usual, in the way of preparing numerous memoranda of information in answer to special inquirers.

'It has been attempted also, in the various annual reports, to meet the public needs along these lines by collecting from trustworthy sources all the facts available regarding one or two economic minerals or mineral industries and to present these in the form of special articles. It is hoped in this way to gradually cover the whole ground, so that inquirers may find in these reports, in epitomised form, all the available data on these matters, together with references to the literature of the subject where those so desiring may find more detailed descriptions. Wherever possible it is intended to supplement this information by studies in the field and on these lines the last annual report will be found to embody the results of a preliminary examin-

Statistics and Mines—*Cont.*

ation of the gas and oil districts of Ontario made by Mr. Theo. Denis of the section.

Issue of reports.

'The annual report for 1898 was finished toward the end of the following year, as soon as the complete information required became available. It was preceded, however, on February 21, 1899, by an advance statement of the mineral production of Canada for 1898. Besides the usual office duties connected with the above-mentioned work, the section has been engaged in the preparation of a technical descriptive catalogue to accompany the mineral exhibit of Canada at the Paris exhibition.'

Mr. Ingall spent a short time in the Buckingham phosphate and graphite mining district, Quebec, on field work with Professor Osann, of Germany.

PALÆONTOLOGY AND ZOOLOGY.

Work by Mr. J. F. Whiteaves.

Mr. Whiteaves reports that, having been elected vice-president and chairman of the Geological and Geographical Section of the American Association for the Advancement of Science for the meeting held at Columbus, Ohio, in August last, it became his duty to prepare and deliver a suitable address on that occasion. The subject chosen was the Devonian System in Canada, and it was treated from a palæontological rather than from an economic point of view. In this address an attempt was made to give a brief but reliable historical sketch of the discovery of Devonian rocks, and a summary of the latest state of our knowledge of these rocks, in every province and district of the Dominion. Its preparation necessitated much careful research and the verification of a large number of statements. It was delivered at Columbus on August 21, and advance copies, printed by the association, were distributed at the meeting and to geologists elsewhere. In this shape the address makes a pamphlet of thirty-one pages, octavo. It is printed *in extenso* in the Transactions of the Association for 1899, and had previously been published in *Science* and in the *American Geologist* for October last.

Mesozoic Fossils.

'The manuscript of the fourth part of the first volume of *Mesozoic Fossils*, referred to in the last year's Summary Report of this department, as having been written, has been revised for publication, and is now in the printer's hands. It will be illustrated by seven full page and for the most part lithographic plates. The drawings for these plates have been made by Mr. Lambe, and the plates themselves have been printed off. It is expected that the complete part will be ready for issue early in 1900.

Palæontology and Zoology.—*Cont.*

Trenton fossils from Akpatok.

'A small collection of fossils from Akpatok Island, Ungava Bay, Ungava, made by Dr. R. Bell, while accompanying the Hudson Bay expedition despatched by the Canadian government in 1897, in the *Diana*, has been critically examined, and a paper upon them has been written and published in the *American Journal of Science* for June, 1899. These fossils are of special interest to the geologist, as they clearly indicate the existence of the Trenton limestone at that far distant and previously unexplored locality. Among them there were a few duplicates, which were sent to the United States National Museum, in exchange for a small series of fossils recently collected from the Trenton formation at Silliman's Fossil Mount, Frobisher Bay, Baffin Land.

'Several other collections of fossils, and more particularly some small consignments of specimens from the Corniferous limestone near Amherstburgh, Ont., have also been examined, and the species determined as far as the state of their preservation would permit.

Report on marine invertebrata.

'In view of the fact that the federal government has recently established a marine biological station at St. Andrews, N.B., a commencement has been made of a report on the marine invertebrata of the river and gulf of St. Lawrence and Atlantic coast of Canada, with the view of placing upon record the exact state of our knowledge of the subject up to the present time. This report is intended to consist of as complete a list as possible of all the species dredged or otherwise collected, from the United States boundary to the Strait of Belle Isle, not only by Dr. W. Stimpson, Sir J. W. Dawson, Dr. R. Bell, Prof. A. E. Verrill, Dr. A. S. Packard, the writer, and others, but also of those dredged off Halifax by H.M.S. *Challenger* in 1872, and in the Bay of Fundy and Atlantic coast of Nova Scotia by the United States Fish Commission. It will be based upon notes that have been accumulated since 1873, and in it the geographical and bathymetrical range of the different species will be given as far as practicable, also notes on their synonymy and specific affinities. Considerable progress has been made with the manuscript of this report.

'Two collections of the recent land shells of New Brunswick have been examined and named for Mr. G. W. Bailey, of Fredericton.

Work by Dr. H. M. Ami.

'Dr. Ami reports that he has continued the work of determining geological horizons from collections of fossils. These comprise specimens collected from the Ottawa Palæozoic basin, also collections sent in by Prof. L. W. Bailey, of the University of New Brunswick, from the slate belt of York and other counties in New Brunswick. The last

Palæontology and Zoology —*Cont.*

named collections show that portions at least of the slate belt are Silurian rather than Ordovician. The collections recently made by himself and others from the Carboniferous rocks of Nova Scotia, have been submitted to a preliminary examination. The field-work was preceded by a study of the literature of similar geological formations in other countries.

Examination of Carboniferous limestones.

'In August, he received instructions to go to Nova Scotia and New Brunswick to examine the marine Carboniferous limestones and associated formations and obtain such palæontological evidence as might serve to fix their true position. Numerous fossils were obtained from these limestones at the following localities :—Near Queenstown, P.O.; at Gilbert Merritt's lime-kiln, in the parish of Hampstead, Queens county, N.B.; Rush Hill, parish of Wickham, Queens county, N.B., Petitcodiac, Westmoreland county, N.B.; and from Kentville Creek, Johnsons Brook and Brookfield in Cumberland and Colchester counties, Nova Scotia. Some of these limestones appear to indicate the presence of the Windsor formation.

'An extensive collection was made of the fossils from the Brookfield limestone of Colchester county, N.S., in which some thirty species were recognized. These fossils have as yet only been subjected to a preliminary examination, but provisional lists of the species have been prepared.

Fossils of the Windsor series.

'From an outcrop of limestone at the mouth of Kentville Creek, in Cumberland county, and near the head of Pugwash Basin, he obtained an interesting series of marine Carboniferous fossils belonging to the same horizon as the Brookfield and Windsor limestones of Colchester and Hants counties. The fossiliferous limestones from these three localities, may be taken as typical of the marine sediments in the counties mentioned, and are therefore classed together as representatives of the Windsor formation, a term adopted from Sir William Dawson's designation "the Windsor series" as applied to the same sediments. The Windsor formation as developed on Kentville Creek forms an interesting outcrop of highly fossiliferous limestone, the organisms being preserved for the most part in concretions or nodules of impure limestone. Bands of impure limestones and limestone-conglomerate also occur along the Joggins and Minudie shores in Cumberland county, interstratified with the sandstones and shales of the Minudie section, but no fossils were found in them. The shales, however, proved to be highly fossiliferous, at Minudie as well as along the valley of the Wallace River to the east, where the measures occur in the form of a large denuded anticline. Estherians, remains of insects, Anthrocomyæ and ferns were found in these shales. The insect wings,

are apparently referable to the *Palæodictyoptera* and the family *Gerarüdæ*, *Estheriaidæ* and *Ostracoda* were also obtained. The physical conditions under which these beds were deposited must have closely resembled those characterizing the deposit of the Coal Measures proper. Palæontology and Zoology —*Cont.*

'At Mr. Hugh Fletcher's suggestion, and while in the Cumberland coal-field, Dr. Ami examined the fossiliferous shales and sandstones of Capt. Henry Mills' Brook in the valley of the Maccan River. These he believes, represent the same geological horizon as those of the beds at Leamington and also near Springhill mines. From the marine limestones of the north-eastern flank of Claremont Hill, at Johnson's Brook, some fifteen species of fossils were obtained belonging to the horizon of the Windsor formation. Limestones referable to the same formation were subsequently examined at Summer Hill Brook on the Nerepis River, three miles west of Summer Hill settlement, in Queens county, N.B. Cumberland coal-field.

'While in Dorchester, New Brunswick, Dr. Ami, with the acting warden of the maritime penitentiary, examined the tilted and considerably disturbed and unevenly bedded sandstones and conglomerates of the Millstone Grit, which crop out immediately north of the present wooden wall of the penitentiary, with a view to ascertain their fitness for building purposes. The greater part of the rock is unfit for this purpose, but some portions of the ledges will furnish building stone of smaller sizes 5′ x 5′ x 2′ down. The rock is in part conglomerate and in part a freestone which hardens when exposed to the air. Building stone in Dorchester.

'The collections of fossils made during the past three seasons in Nova Scotia and New Brunswick* have been catalogued and placed in drawers in geographical order, for further study or reference.

'With a view of determining the relations of the Carboniferous and Devonian rocks of Nova Scotia and New Brunswick, several collections of fossil plants, crustacea and fishes from various localities in these provinces were forwarded to Mr. Robert Kidston, F.G.S., of Stirling, Scotland, and to Dr. A. Smith Woodward of the British Museum. Carboniferous and Devonian.

'The following are some of the conclusions to which Mr. Kidston has arrived from the evidence of the fossil plants. These, as well as those arrived at by Dr. White, subsequently referred to, have already been quoted by Mr. Whiteaves in his address before the American Association, for the Advancement of Science at its last meeting. Referring to the fossils of the Horton formation Mr. Kidston writes:— Report by Mr. Kidston.

'"These rocks appear to be undoubtedly Lower Carboniferous.... There is no evidence at all to support the opinion that they are of

*Erratum.—In Sum. Rep. for 1897, p. 135, omit *Cyclopteris (Ancimites) Acadica* and *Lepidodendron corrugatum*.

Palæontology and Zoology —*Cont.*

Devonian age.... All the evidence derived from a study of these fossils points very strongly against this view."

'Of the Riversdale plants, Mr. Kidston writes:—"The two divisions of this series, the Riversdale and Harrington River rocks, may be treated together, as they contain the same fossils and are evidently of the same age. The whole of the plants from the Riversdale series have a most pronounced Upper Carboniferous facies and markedly possess the characteristics of a Coal Measure flora. Judged from an European comparison, no other conclusion can be arrived at."

'Bearing upon the question of the identity of the flora of the Riversdale rocks of Nova Scotia with the Lancaster formation in New Brunswick, Mr. Kidston says:—"The question of the age of the Riversdale series is inseparably connected with the question of the age of the plant beds of St. John, N.B. The species contained in the Riversdale series are also met with in the St. John plant beds, where however, a greater number of species has been discovered. I do not wish to express my views as to the age of the St. John plant beds too strongly, but from what I have been able to learn from a study of the literature of the subject and an examination of specimens from these beds, it appears to me that they possess a flora of a much higher horizon than that assigned to them, and that in reality they are most probably Upper Carboniferous."

Opinion of Dr. D. White.

'Dr. David White, of the U. S. Geological Survey, who, when in Ottawa some time previously had examined many of the plant remains from the formations above referred to, has also kindly communicated his opinion in regard to the horizons represented. He states:—"(1) That the plant-bearing portion of the Horton series of Nova Scotia, as shown by Sir William Dawson in 1873, is nearly contemporaneous with the Pocono formation of the eastern United States, which has long been assigned to a basal position in the Carboniferous system. (2.) That the Riversdale series of Nova Scotia (which Sir William Dawson referred to the Millstone Grit) is of Carboniferous age and assuredly newer than the Horton series. (3.) That the plant bearing beds near St. John, N.B., are not Middle Devonian as had previously been supposed, but Carboniferous, and that they are the exact equivalent of the Riversdale series of Nova Scotia."

Statement by Dr. H. Woodward.

'In a paper by Prof. T. Rupert Jones and Dr. Henry Woodward, published in the *Geological Magazine* for September, 1899, in which two specimens of a protolimuloid crustacean from the Riversdale formation of Nova Scotia are described under the name *Belinurus grandævus*, these authors regard the Riversdale rocks as of Lower Carboniferous age. Prof. T. Rupert Jones also has come to a similar

conclusion, on the evidence of some fossil ostracoda and phyllopoda sent to him in 1898. Palæontology and Zoology —*Cont.*

'Dr. A. Smith Woodward reports upon the fish remains as follows :—

'"From the shales of the Riversdale formation near Eastville on the Stewiacke River, Colchester county, N.S.—The specimen from the Stewiacke River is determined by Dr. Traquair to be a Palæoniscid clavicle. The genus is doubtful, but is almost certainly of a Carboniferous type. Dr. A. Smith Woodward on fish remains.

'"From the shales of the Horton formation, Horton bluff and Trenholm Brook, Kings county, N.S. The Horton fossils are certainly Carboniferous, but are not enough to determine whether Upper or Lower. The pieces of bone-bed exhibit scales of *Elonichthys*, species of *Acanthodes*, and one imperfect clavicle of a Rhizodont (probably *Strepsodus*. The fine piece of jaw is a dentary of *Strepsodus Hardingi*, Dawson, sp.

'"From the shales and calcareous sandstones of McArra Brook, Antigonish county, N.S. The specimens from McArras's Brook are extremely interesting and represent the base of the Lower Old Red Sandstone of Britain. "The Pteraspidian remains are sufficient to prove that they belong to the genus *Pteraspis*. Both dorsal and ventral shields are so much like those of *P. Crouchii*, that if these Nova Scotian fossils had been found in the west of England we should have referred them to the latter species. Perhaps the rostral plate may prove to distinguish your form when it is completely known. One piece of dorsal shield, in counterpart, shows the impressions of the supposed branchial pouches on one side. The pointed fragments may be Cephalaspidean cornua, but are uncertain.

'"There is the typical *Onchus Murchisoni*, Ag.

'"Most interesting is one small fragment of *Psammosteus*, with ornament identical with that of *Psammosteus Anglicus* (see Traquair, Ann. Mag. Nat. Hist., ser. 7, Vol. II, 1898, p. 67, pl. I, figs, 1, 2.) In this fossil the chambers of the middle layer are larger than in our unique plate.

'"On the whole, I should place the McArra Brook beds on the same horizon as the Old Red cornstones of the Hereford district of England, above the passage beds."

'It will thus be seen that Mr. David White's and Mr. Kidston's views on the fossil plants of the Riversdale formation and Horton series; and those of Dr. A. Smith Woodward upon the fossil fishes of the Horton, as well as his well known views on the age of the Albert Coincidence of opinions given.

Palæontology and Zoology —*Cont.*

shales of New Brunswick; also the views of Prof. T. Rupert Jones and Dr. Henry Woodward on the evidence afforded by the Ostracoda and Crustaceans; concur in placing these formations in the Carboniferous system.

Determination of fossils.

'During the early summer months, some time was spent by Dr. Ami in determining and making lists of the species in collections made by Dr. R. W. Ells, Mr. W. J. Wilson and the late Mr. N. J. Giroux, in eastern Ontario. Some days were also spent in the field with Dr. Ells in the same region, for the purpose of defining the geological horizons by means of the fossils. The principal results are noted by Dr. Ells in his report on a previous page. Details, with lists of fossils, are reserved until the publication of the maps. Collections made by Prof. L. W. Bailey in New Brunswick, were also examined, of which the results are quoted by Prof. Bailey in his report in this summary. Several collections sent in for identification were likewise dealt with.

'In the early part of the summer, Dr. Ami completed a report on some Cambro-Silurian and Silurian fossils from Lake Temiscaming, Lake Nipissing and Mattawa outliers. This has since appeared as an Appendix to Mr. Barlow's report on the Nipissing and Temiscaming region.

Borings in Ontario.

'A number of drillings from Montreal and from the counties of York and Lambton, Ontario, were examined with interesting results in some cases. The existence of several hundred feet of bituminous shales and limestones in the south-eastern corner of Lake Huron was ascertained, which indicate a possible modification of the limits of the Portage and Genesee, the Chemung and Hamilton formations of that region.

Museum work.

'Time was also found by Dr. Ami to prepare several small collections of fossils for educational institutions from duplicate material on hand.

'The various additions to the Ethnological collection of the Museum made during the year have been duly entered and recorded, and some of them placed in the Museum.

'During the year Dr. Ami has also prepared papers on the following topics with special reference to Canadian geology. On the Subdivisions of the Carboniferous System in Eastern Canada, read before the Nova Scotia Institute of Science, Halifax. On a Collection of Fossils from the Trenton formation of Cumberland, Ontario, made by Prof. T. Slater Jackson, in 1890. On the occurrence of *Belinurus grandævus*, a New Species of Palæozoic Crustacean recently described by Prof. T. Rupert Jones and Dr. Henry Woodward from the Eo-Carboniferous

of Riversdale, Nova Scotia. On a New or hitherto Unrecognized Geological Horizon in the gas and oil region of Western Ontario, Canada.' Palæontology and Zoology —*Cont.*

Mr. L. M. Lambe reports as follows :— Work by Mr. L. M. Lambe.

'The greater part of my time during the past year has been occupied in completing a revision of the genera and species of Canadian Palæozoic Corals. The manuscript of this report, to form the second part of the fourth volume of *Contributions to Canadian Palæontology*, is now finished, and gives the results of a study of the Aporosa and the Rugosa, two groups of madreporarian corals. Descriptions are given of ninety-four species, included in twenty-four genera. Drawings, composing thirteen plates, for the illustration of this report, have also been prepared.

'The first part of the fourth volume of *Contributions to Canadian Palæontology*, consisting of a revision of the Madreporaria Perforata and the Alcyonaria, has been printed. It contains descriptions of seventy-four species, with some varieties, belonging to twenty-two genera, making nearly one hundred pages of text, illustrated by five plates of figures.

'These two reports, together, will form a monograph on Canadian Palæozoic Corals that, it is hoped, will prove of use in leading to a better understanding of the numerous species of fossil forms of the Zoantharia and the Alcyonaria, as regards their structure, their specific and generic relations to each other and their range in geological time. Determination of sponges.

'Two years ago the examination of a collection of calcareous, monaxonid and tetractinellid recent sponges from the Gulf of St. Lawrance, Labrador, Greenland and the Arctic Ocean, belonging to Professor D'Arcy Thompson, of University College, Dundee, Scotland, was undertaken, with a view to publishing any results arising therefrom that might prove of interest from a zoological standpoint. Considerable headway has been made with this collection, the preliminary work, principally the preparation of microscopic slides, being done as time permitted, for the most part out of office hours. Since the middle of November my time has been almost entirely devoted to the determination of the Calcarea, which, from their generally small size and complex structure, offer somewhat increased difficulties to a satisfactory elucidation of their specific characters. Some of the forms in the collection are apparently undescribed, and it is hoped that a paper with explanatory figures will shortly be ready that is intended to supplement the one already published on the sponges from the Atlantic Coast of Canada.

Palæontology and Zoology —*Cont.*

'Drawings were prepared, in the early part of the year, for six plates, viz., XXXIV. to XXXIX. inclusive, illustrating Part IV., Volume I. of *Mesozoic Fossils.*

Contributions to museum.

'The following is a list of specimens collected by, or received from, officers of the staff, during the year 1899 :—

Professor Macoun :—

Pair of the Ipswich Sparrow, and of the Common, Arctic and Roseate Terns ; four sets of eggs of the Arctic Tern ; and a collection of marine invertebrata ; all from Sable Island, Nova Scotia.

Dr. R. W. Ells :—

Black River fossils from Point Seche and other places along the north side of Lake Coulonge, Ottawa River ; also from a quarry on the line of the Cornwall and Ottawa Railway, about half a mile south of Embrun station.

Drs. R. W. Ells and H. M. Ami :—

Black River limestone fossils from the quarries at Glen Robertson, on the Canada Atlantic Railway, and from a quarry on the River à la Graisse, in East Hawksbury.

Dr. R. W. Ells (per Howells Fréchette) :—

Set of thirty-three eggs of the Snapping Turtle (*Chelydra serpentina*), and one, containing the very unusual number of ten eggs of the Bronzed Grackle (*Quiscalus quiscalus æneus*), from Manotick, Ont.

A. P. Low :—

Skeletons of Cross Fox, and Marten.

Skin of Bearded Seal.

Skins of male and female Goshawk, Rough-legged Buzzard, Pigeon Hawk and Kittiwake.

Set of eggs of the Goshawk, Redpoll, White-crowned Sparrow and Black Guillemot.

Collection of eggs from Nachvak and Fort Chimo, Ungava.

Specimens of carved walrus ivory from Hudson Bay.

Two Eskimo bows and arrows and a fish spear.

Skeleton of Polar Bear, presented by Rev. W. G. Walton, of Fort George.

Fifteen skins of hawks, ducks, &c., presented by Miles Spencer, of Fort George, Hudson Bay.

W. McInnes :—

One skull of black bear ; two skulls of fisher (male,) and one of fisher, (female) ; also a collection of beaver gnawed wood, beaver teeth, &c., from the Rainy River district.

Contributions to museum —*Cont.*

Dr. H. M. Ami :—

Large collections of fossils from the Devonian and Carboniferous rocks of southern New Brunswick and northern Nova Scotia, from the Cambro-Silurian (Ordovician) rocks of the eastern part of the Ottawa basin, and from the Pleistocene deposits of the Ottawa valley.

A. E. Barlow :—

Set of eggs of the Spotted Sandpiper, of the Night Hawk and Brown Thrasher ; from Peterborough county, Ont.

R. W. Brock :—

Indian stone pestle, from Burton City, B.C.; and pair of West Kootenay ' bear-paw ' snowshoes.

D. B. Dowling :—

Twenty fossils from the Niagara formation of Moose Lake, Saskatchewan.

J. C. Gwillim :—

One fossil from Willow Creek, Atlin, B.C. ; and an obsidian arrowhead from Atlin Lake.

The additions to the palæontological, zoological and ethnological collections from other sources during 1899, are as follows :—

By presentation :—

(A.—*Palæontology.*)

U. S. National Museum, Washington, D.C. :—

Twenty specimens of eleven species of fossils from the Trenton limestone at Silliman's Fossil Mount ; and two ventral valves of *Obolella crassa*, Hall, from the Lower Cambrian rocks at Troy, N.Y.

Colonel C. C. Grant, Hamilton, Ont. :—

180 fossils from the Cambro-Silurian drift at Winona, Ont., and from the Clinton and Niagara formations near Hamilton.

T. C. Weston, Ottawa :—

Fine specimens of *Cheirurus Apollo*, *Bathyurus Saffordi*, and four other rare fossils from the Lévis rocks at Point Lévis, P.Q. ; and fifty fossils from the Mountain Hill rocks at Quebec City.

T. J. Pollock, B.A., Aylmer :—

Two specimens of *Coscinium proavium* (Eichwald ?) Billings, from the Black River formation at Aylmer.

Contributions to museum —*Cont.*

J. J. Carter, Manilla, Ont. :—

Fine specimen of *Calymene senaria*, Conrad, from a loose piece of limestone on lot 6, township of Brock, Ontario county, Ont.

Joseph Boyle, Dawson, Yukon District :—

Portion of tusk of Mammoth, from Quartz Creek, Klondike district.

(B.—*Zoology.*)

S. Short, Rockliffe, Ottawa :—

Specimen of Saw-whet Owl (*Nyctala Acadica*) from Rockliffe.

Captain W. Thorburn, Pine Lake, Alberta :—

Full set of eight eggs of the American Magpie (*Pica pica Hudsonica*) from Three Hills Creek, Alberta.

Dr. A. Horsey, Ottawa :—

Male Horned Lark (*Otocoris alpestris*), in the flesh, from the vicinity of Ottawa.

G. F. Dippie, Toronto :—

Set of eggs, consisting of six eggs of the American Coot (*Fulica Americana*), and two of the Lesser Scaup Duck (*Aythya affinis*) taken June 14th, 1896, at Burnt Lake, Alberta.

Aubrey Rowan-Legge, Ottawa :—

Set of four eggs of the Purple Finch (*Carpodacus purpureus*) with one Cowbird's egg, from Hull, P.Q.

W. H. Harrington, Ottawa :—

Fine specimen of the Glass-rope Sponge (*Hyalonema Sieboldii*, Gray), from Vries Island, Bay of Tokio, Japan.

A. McL. Hanks, Tacoma, State of Washington :—

One specimen each of *Panopæa generosa*, Gould, and *Zirphœa crispata*, L., from Tacoma.

J. Schupe, Mahone Bay, N.S.:—

"Sword" of Swordfish (*Ziphias gladius*), from the Grand Bank, Newfoundland.

J. C. Lantz, Mahone Bay, N.S. :—

Another "sword" of Swordfish, from the Grand Bank.

Edwin Beaupré, Kingston, Ont. :—

Adult male of the Arctic Three-toed Woodpecker (*Picoides arcticus*) from Kingston. In the flesh.

— Courbeaux, Prince Albert, Sask.:—

Skin of Cowbird, of Lapland Longspur, Western Vesper Sparrow, Western Savanna Sparrow and Fox Sparrow.

Contributions to museum —*Cont.*

W. Spreadborough, Bracebridge, Ont. :—

Twelve specimens of five species of fishes, seventeen specimens of seven species of snakes, and twenty-four specimens of nine species of batrachia, from Ontario.

(C.—*Ethnology.*)

J. J. Carter :—

One stone adze, a stone sinker, four stone disks, eleven pieces of pottery, an ancient iron axe head, and four copper implements, from North Orillia, Simcoe Co., Ont.

A. P. Low, Ottawa :—

Fine model of Kyak, from Ungava Bay ; and lower lip of bear, used by Indians as a charm, from Fort George, Hudson Bay.

By exchange :—

One egg of Puffin, and set of three eggs of Cormorant, from Labrador ; egg of Whistling Swan, from Mackenzie Bay ; two eggs of the Great Horned Owl, from Scarborough, Ont. ; and set of five eggs of the Great Crested Flycatcher, from near Toronto.

By purchase :—

Set of seven eggs of Holbœll's Grebe, from Alberta ; set of five eggs of the Downy Woodpecker, one of two eggs of the Whip-poor-Will, from Port Hope ; set of four eggs of the Scarlet Tanager, and one of six eggs of the White-breasted Nuthatch, from Ontario ; and set of four eggs of the Red-breasted Nuthatch, from Alberta.

From C. Hill-Tout, Vancouver, B.C.—

Collection of about 250 Indian implements, &c., and two remarkably deformed Indian skulls, from British Columbia.

From A. Aaronson, Victoria, B.C.:—

Ethnological collection of over 500 objects from the coast region of British Columbia.

NATURAL HISTORY.

Work by Prof. J. Macoun.

Professor Macoun reports as follows on the work done by himself and by his assistant, Mr. James M. Macoun :—

'During the winter months, after the date of my last report, I was engaged principally in the routine work of my office, which included the determination of a great many specimens from collections in all parts of the Canada. My own collections on Cape Breton Island

Natural history-*Cont.*

and Mr. Spreadborough's in the neighbourhood of the Yellow Head Pass in the Rocky Mountains, were arranged and named. Some time was also devoted to the revision and completion of the manuscript for Part VII. of my catalogue of Canadian Plants which will include the Lichens and a revision of what has already been published on the Mosses and Liverworts.

'Early in June, my assistant Mr. J. M. Macoun, was placed in charge of the Canadian forestry exhibit at the Paris Exhibition, and much of his time since that date has been devoted to the collection of specimens and other work in connection with that exhibit.

'My assistant being otherwise engaged, no plants have been got out for mounting since last spring, nor have any duplicates been distributed from the herbarium. Between January and May, 826 sheets of plants were distributed, and 1,487 sheets were mounted and placed in the herbarium.

Catalogue of Canadian birds.

'Immediately upon my return from the field, in September, the manuscript for Part I. of a catalogue of Canadian Birds was sent to the printer. This catalogue will include all our Canadian species between the Pygopodes or Diving Birds and the Columbæ or Pigeons, about 300 species. The distribution and breeding habits of each species is given, my sources of information being all available publications dealing with Canadian ornithology and a great mass of unpublished material, the result of my own observations and those of other members of the Geological Survey staff, as well as of many other naturalists throughout Canada.

Plant collections from Yukon and Atlin.

'During the past season, besides my own collections in New Brunswick and on Sable Island, the more valuable received have been from Mr. J. B. Tyrrell, who collected at Dawson and vicinity, and Mr. J. C. Gwillim, who collected in the Atlin district of British Columbia.

'The material received from Mr. Tyrrell shows that the summer climate of Dawson is little inferior to that of the Ottawa valley 200 miles north of Ottawa. That the climate would change for the better as soon as the coating of moss and the dense forest is removed is shown by the early flowering of the Anemone (*Anemone Nuttalliana*) which occurred on the first of May, and other species coming in quick succession thereafter. These flowers grew along the dry slopes of the Yukon where the snow melted early.

'Mr. Gwillim's collections are interesting in showing that the general flora of the lower altitudes of northern British Columbia is much alike. An increase in the altitude brought in species that are limited in range and in some instances new to the flora. Four interesting species were gathered on July 22 on a mountain above Atlin Lake at

an altitude of 5,700 feet above the sea. These were *Geranium erianthum*, *Aconitum delphinifolium*, *Pedicularis capitata*, and an Astragalus, which I believe is new to science. Natural history–*Cont.*

'Large collections, including many hundred specimens, have been determined from Prince Edward Island, Quebec, Ontario, Rocky Mountains and British Columbia. The chief of these were received from the Rev. Mr. Ducharme, Rigaud, Que., from William Scott, B.A., Head Master of Toronto Normal School, from Mr. William McCalla of St. Catharines, Ont., from Mr. Sanson, Banff, Rocky Mountains, and from the Department of Agriculture, British Columbia. Other collections determined.

'Under your instructions I made, during the past summer, a careful investigation of the fauna and flora of Sable Island, and a part of New Brunswick. In making an examination into the climatic conditions prevailing in the St. John valley, as affecting the vegetation of that region, I thought it advisable to see that part of Maine bordering on New Brunswick. At Fort Fairfield, near the International boundary, I met some members of the Maine Botanical Society, and with them travelled through that part of Aroostook county, known as the "Garden of Maine." I next went to Woodstock on the St. John River where I remained for over a week. While there, I made a thorough examination of the flora of that region, listing 627 species of plants. These, without exception, indicated a climate suitable to all kinds of farming. This statement applies to the whole valley of the St. John River, from ten miles below Woodstock to Edmundston, one hundred miles above it. Field work.

'Later in the season I spent two weeks in the St. John valley and examined the country in the vicinity of Aroostook Junction, Grand Falls and numerous other points, and everywhere found rich soil, luxuriant vegetation and bad farming. It is quite true that the hills in many places are steep and therefore difficult to cultivate, but even in the best districts the methods followed by most of the farmers are not such as to give the best results. St. John valley, N.B.

'Much of the valley is especially adapted to fruit-growing, and I saw several large orchards, but these like the agricultural lands, showed great neglect and ignorance of scientific methods of caring for fruit-trees. In one very large orchard, the trees were planted so close together that their tops formed a complete cover for the whole surface of ground below them. Many trees in this orchard, and others I visited, had been killed by mice, hundreds having been girdled in this one orchard in the winter of 1898–99. This was not to be wondered at, as the heavy growth of grass of the preceding season had Fruit growing.

Natural history–*Cont.*

been left standing in the orchard and fence-corners, thus forming excellent breeding-places for the mice. This great destruction of fruit-trees could be prevented there, as it is elsewhere, by careful culture. Most of the fruit grown is either fall or summer apples. Growing on trees which stood so close together that their branches interlocked none but the fruit on the upper branches had sufficient light and air to attain a merchantable size. Early in September I saw heaps of the smaller apples under the trees; these were being barrelled and sold at prices that would hardly repay the labour expended. The fact that the sides of the trees next roads or cultivated fields bore good fruit, was conclusive proof that the poor fruit which grew in these orchards was due neither to bad soil nor to unsuitable climatic conditions but to the wrong methods of cultivation which are followed.

Indifferent farming.

'In many respects the farms in the region visited are like those in Cape Breton Island. There is little system and hence little success. Much of the country is well adapted to dairying and sheep-raising, but as yet few attempts have been made to take advantage of natural conditions which will ensure success, if to them is added the practical knowledge which is necessary. Though some progress has been made in dairying, much remains to be done. As to fruit-growing, I have no hesitation in saying that just as good results could be obtained in the St. John valley as in the Annapolis valley if the same knowledge existed among the farmers and the same care was taken of the trees.

Sable Island.

'Through the courtesy of Major F. Gourdeau, Deputy Minister of Marine and Fisheries, I was conveyed to and from Sable Island on a government ship, and I have to thank Mr. Jonathan Parsons, the marine agent at Halifax, Capt. Campbell, of the *Newfield*, and Supt. Boutellier and his family on the island, for many kindnesses and such assistance as they were able to render me in the prosecution of my work.

Its appearance.

'In the forenoon of July 20, I reached Sable Island and landed near the main station. I was agreeably surprised later to find that practically the whole island was covered with verdure, though the whole extent of the subsoil and most of the surface was pure sand and without any admixture of humus. Sand-hills as I have seen them along Lake Ontario and in the North-west, consisted of raw sand without vegetation, and this was what I expected to see on Sable Island; but this idea was dissipated at once, on landing.

'During the five weeks I remained on the island, I endeavoured to investigate everything connected with its natural history. In the

following short report, I will give the general results of my observations :— Natural history–*Cont.*

'The island itself is a mass of pure sand and at one time occupied a very much larger space than it does at present. One fact stands out prominently that the island is constantly decreasing in size, and can never increase except by an elevation of the land. The popular opinion that as it wastes in one part it makes in another is fallacious. Another erroneous idea is that the wind wastes the hills and levels the land and causes destruction. The wind is a builder and the sea is the leveller. The wind certainly shifts the sand but it cuts out in one place only to build up in another. By it the sand is blown inward, but none to sea, except perhaps to a small extent during a very heavy gale. On the other hand, the currents that are set in motion by the winds, and others of a permanent character, are constantly cutting away the sand and carrying it out to sea, and if a high tide should throw some of this back, which it often does, the wind, by blowing this inward, at once begins to build up new hills. Whenever there is the slightest obstruction a mound is formed, sand-wort (*Arenari pepoides*) immediately takes possession, and so year by year the mound grows higher and soon sand-grass (*Ammophila arenaria*) gets a foot-hold and the building grows apace, till a hill may be found where a few years before the surface was on a level with the water. In some parts of the island, notably the north side, the wasting action of the sea is not very great. The chief waste is now taking place between a point about nine miles east of the West End Light and the extreme western point on the south side. Wind and sea action.

'Opinions have been expressed that the sand is stratified, but these opinions are founded on imperfect observation. From one end of the island to the other the sand is the same, being chiefly quartz mixed with a little black sand containing garnets. The apparent stratification is merely the yearly layers laid on by the wind in winter. It has also been stated that there are considerable deposits of black or magnetic-iron sand in various parts of the island, but this is not the case. The black sand, in small quantity, is disseminated throughout the whole mass ; but it is only under exceptional conditions that it becomes large enough in quantity to be noticed. Sand deposits.

'The physical features of the island are peculiar, and if thoroughly studied would add many interesting facts to those already known. All old accounts make the island very much larger than it is now and give much greater heights for its hills, of which the highest are now but little over 100 feet. When the Admiralty survey of the island was Island decreasing in size.

Natural history—*Cont.*

made in 1799 it was found to be thirty-one miles long and two broad, though according to the older French charts it had been forty miles in length and two and one quarter in breadth. Lieut. Burton, who surveyed the island in 1808, found it to be thirty miles long and two wide.

Lagoon.

'In the earliest accounts of the island, we read of a lagoon that extended at least twenty miles from east to west. The sea has so encroached upon the land as to cover part of this lagoon, the sand-bar which separates the present lagoon from the sea covers another part of it, and the part that remains is only eleven miles long, and is so filled with sand that last summer it was in places only six inches deep.

'Until 1836, there was a wide opening from the sea on the south side near where the West End Light now stands. In that year it closed, and two vessels were caught in the lagoon, which then became a lake. Prior to this we have accounts of the dangers of Sable Island, but nothing to indicate that it had no harbour. From a careful examination of all the surroundings, I am of the opinion that when Sable Island rose out of the sea after the Glacial submergence it was of great extent in an easterly and westerly direction. That it was either two high banks of sand with an opening at each end and deep water between, or had the form of an atoll with an opening to the south and deep water within, so that, up to 1836 there was a harbour for small vessels in the lagoon. This opinion is borne out by the lagoon itself, as it is deeper at present in some places than the sea around the island for nearly a mile out. The fresh-water ponds are in hollows and were parts of the old lagoon which were not filled up completely by the advancing sand. In a few years the lagoon will be entirely filled with sand and a few of the deeper spots will become fresh-water ponds.

Sand-hills along the coast.

'In the earliest times the outer line of the island was the highest part just as it is now, and there is no doubt that 200 years ago the hills forming the outer fringe were as high as the old navigators stated, but the action of the wind cutting in the hill on the sea-face and forcing the sand over the crest of the hill or up the gullies which are being constantly cut in the sea face. The new hills never attain the height of the old ones as part of the sand is taken away by the sea and finally lost. This movement is unceasing, and by its action the island is constantly getting narrower and the hills lower. Less than ten years ago sand-hills extended all along the south side, and large quantities of hay were cut on them. Five miles of these hills have been destroyed and the sand blown into the lagoon; but already, as mentioned above, new mounds are being formed and will grow until the sea reaches their seaward face and then they also will disappear.

'All the sand-hills are covered with sand-grass *(Ammophila)* and the wonderful vigour of this grass is well shown everywhere, but more particularly where the sand has just been deposited, or is in a raw state. I found one underground stem or stolon over twelve feet long which had sixty-four series of roots and no less than forty-seven tufts of leaves. The growing point was so hard and sharp that it might almost penetrate wood. This one species of grass with the wild pea *(Lathyrus maritimus)* constitutes the bulk of the wild hay cut for winter fodder and the winter pasturage of the wild horses. As the sand encroaches on the old land, this grass grows with it and covers it, except near the stations where the grass is worn off, and then the wind soon shows its power by making gullies of great depth.

Natural history-*Cont.*
Sand-grass and wild pea.

'What I term the old land is that part of the island not yet encroached upon by the sand from either side. In this old land are to be found the fresh-water ponds and old ridges and flats covered by *Empetrum nigrum* (crowberry), and the few low-growing shrubs that constitute the woody plants of the island. Every part of this old land is cut up by paths made by the wild horses and cattle. Year by year these areas are getting less, and many plants formerly growing on the island have no doubt become extinct on account of the sand movement. When cutting commences, it continues until the level is reached where moisture is permanent, and invariably this level is found filled with roots of shrubs that once grew there, but which at present, a few yards away, has from forty to eighty feet of sand over it. The west winds seem to be the most powerful, and they are the ones that cut up the hills at a distance from the beach. These winds force the sands eastward, then follows the Cranberry (*Vaccinium macrocarpon*) which appears immediately and flourishes in the damp sand mixed with a little humus.

Old level of the island.

'The fresh-water ponds are a curious feature of the island east of the lagoon, which is cut off from them by a wide barrier of sand. Near No. 3 station, at the foot of the lagoon, there is a series of ponds with boggy margins which have all the appearance of "quaking bogs." The slight connection between them, with their depth, shows that they were at one time connected with the lagoon. All these ponds and slight hollows have more or less humus around them and in them, mixed with sand. Their margins and all shallow pools with hard bottoms are much frequented by cattle and horses at present and have been in the past as the following observation will show.

Fresh-water ponds.

'As the sea wears away the sand the bottoms of these ponds are exposed, and this bottom material when thrown up on the beach is called peat. It is not peat, but humus mixed with sand as above-mentioned.

Natural history–*Cont.*

Less than two years ago quite a wide bed, having a thickness of a few inches, was exposed on the north-west side where no ponds now exist, and sand-hills fifty feet high occur. This was seen at low-tide. It was noted at the time that it was marked with tracks of cattle and calves which had pastured on it before it was covered by the sand of the advancing hills. Now the hills themselves had been forced further inward, and the hollow where the cattle pastured before the introduction of horses on the island was covered by the sea.

Widest part of island.

'The island is at its widest between Stations Nos. 3 and 4, or from eleven to fifteen miles east of the main station, which is three miles east of West End Light. This is real "old land,' and is also the region of "barrens," (covered with *Empetrum nigrum*) and cranberry beds, not bogs ; for there are no bogs on the island. Along both the northern and southern beaches there stretches a line of sand-hills, running from 60 to 80 feet high, here and there broken into by the sand being cut out by the wind and sent inwards. Stretching from either side towards the interior is a series of low mounds covered very closely with *Empetrum nigrum* and *Juniperus communis* mixed more or less with other shrubby or herbaceous plants. Ninety per cent, however, of the vegetation is crowberry and juniper, both heavily covered with fruit.

Origin of cranberry beds.

'I made a careful examination of the whole interior, and found that about every half mile or more it was crossed by a crescent-shaped ridge of sand, "raw" on the western face, but covered on the eastern slope with the usual sand grass. The winter storms blow out the sand down to where dampness is permanent and there cease to affect the wet sand. This is the cause of the flat beach by the lagoon and the cranberry beds. Always to the west of the base there was a space without any vegetation, and next cranberry vines extending over this in thin beds. In this manner all the cranberry beds originate. They are all on the damp sand, occupying or bordering such places.

Climate.

'The climate of the island is very equable. During the five weeks I remained there the range of the thermometer was only twenty degrees, the lowest reading being fifty-six degrees and the highest seventy-five degrees Fahrenheit. The day temperature is moderated by the sea breeze, while that of the night is moderated by the same means. In ten years the lowest winter reading has been six above zero. The winter storms are always accompanied with the severest cold and this factor causes the winter months to be most disastrous. Taken as a whole, the climate is very pleasant.

'I am inclined to believe that trees have never grown upon the island. On one occasion I saw roots protruding from under a sand-hill over thirty feet high, and on digging them out found that they represented part of the remains of a specimen of *Juniperus Sabina procumbens* (creeping juniper). It was rooted in a layer of black soil and when taken out showed that it had lain flat on the ground. Two of the roots, including the bark, measured $3\frac{5}{8}$ and $3\frac{3}{8}$ inches in diameter respectively, while the crown, where the branches began to spread was over seventeen inches in circumference or nearly six inches in diameter. This growth and others observed under sand-hills indicate long periods of vegetation without encroachment of sand, so that when these shrubs lived, the lagoon was a quiet lake and the north side of the island was miles removed, as no sand reached these localities for many years. Natural history–*Cont.* Probably no trees.

'Though there are no trees on the island and shrubs never attain more than a foot in height, these, if sheltered from the sea air and winter gales attain a considerable size. About fourteen years ago, Mr. Boutellier planted a willow and an elm, both of which are now about five feet high. Every summer they make a fine growth, but during the winter are killed back to the point at which they are protected by an adjoining fence. Even in summer, as I learned from my own observations, the leaves above the shelter of the fence are small and badly formed, and after a strong gale or heavy fog the tender ones become blackened or shrivelled at the edges, while those that were protected were very large and well formed.

'Fuschias and geraniums grown in the open air changed their habit, spreading out instead of growing erect, while their flowers were produced below instead of above the leaves. From these facts I concluded that no deciduous-leaved tree would succeed on the island. Spruce or other conifers would perhaps do better and the experiment is worth trying.

'Mr. Boutellier, who is a good farmer, and a very intelligent man, has succeeded in growing crops and keeping the sand from being blown away. He has learned that the purest sand, with a coat of manure, will grow all kinds of vegetables and the best of hay. When he wants to add a little more to his cultivated ground, he levels the sand, gives it a coat of manure and plants or sows his seeds. If for hay, the question of the retention of the sands is settled at once, as it cannot blow away unless the sod is broken up, and a few inches of sand blown on it only makes it the more secure. Crops grown

'Attempts have been made to farm in some places, but these always resulted in failure, and always will, as the sand is incapable in itself of supplying all that is wanted to mature the plant, and there is not

Natural history–*Cont.*

enough manure made at the stations to do more than fertilize the gardens and some small fields where hay is grown. I saw oats in July with leaves well on to an inch wide, but the oats and brome grass were struck with rust owing to the warm fogs that occurred at that time, and so had to be cut at once.

Plants collected.

'Of flowering plants, 191 species were obtained on Sable Island, and nearly one hundred species of cryptogams. Up to the present I have not had time to determine all the species, but enough is known to show the origin of the flora. All the shrubs are natives of Newfoundland and Nova Scotia. *Empetrum nigrum*, which may be said to be the characteristic plant of the old land of the island, seems to have come when the cold was much greater than at the present time. The herbaceous perennials, except the few introduced, are also of northern origin, but the chief annual, *Sabbatia chloroides*, is of southern extraction. One grass, the sweet vernal grass (*Anthoxanthum odoratum*) of England, is quite common on the old land, and has no appearance of being introduced, yet it has never been recognized as indigenous in America. It is certainly indigenous on the island or a resident of such long standing that it has made itself at home in all suitable places. With the exception of this grass all other introductions are of such recent occurrence that they cannot be mistaken.

Few introduced plants.

'I expected to find many introduced plants on the island, but was surprised to find only thirty all told, and only three of these widely spread. These were white clover, fall dandelion and the sweet vernal grass, which latter may be an introduction. Small patches of clover, timothy, butter-cups, red top, and wild barley, with a few other species, all introduced with other seeds, were seen in meadows. About the buildings were shepherd's purse, lamb's quarter, chick-weed, door-weed, wild buckwheat and a few other species, but none of these could be called plentiful.

Flora of sand-hills.

'The outer sand-hills are altogether covered with *Ammophilla aranaria*, which binds the sands together, and as the whole island is sand, this species is found mixed with other things on the interior mounds and minor elevations. A species of rush (*Juncus Baltic*) is also a permanent species and on the older ridges *Vaccinium Pennsylvanicum*, *Myrica cerifera*, *Empetrum nigrum*, juniper (*Juniperus communis*), ground hemlock (*Juniperus procumbens*) and a few grasses make up the bulk of the flora. Dwarf roses are abundant, but like all the other shrubs, die almost to the ground every winter.

Birds.

'Only about a dozen species of birds breed on Sable Island, and only one of these is a land bird, and this seems peculiar to the island. I refer to the Ipswich sparrow, which, although taken on Cape Cod is

not known to breed anywhere else than on Sable Island. Another land bird—the Canada Nuthatch—possibly bred on the island this year. They were seen in pairs at all the stations, but neither young nor eggs were found. Natural history-*Cont.*

'There are no native mammals on the island, but there are a few foxes which were introduced some years ago for the sake of their fur, but which should be extirpated at once, as they have already stopped the ducks from breeding, lessened the number of terns, and have almost prevented the raising of poultry by the residents at the eastern stations. No native mammals.

'The fresh-water ponds contain a few small fishes, but there are no snakes, frogs or toads. Fishes, &c.

'Both around the shores and in the lagoon where they are not likely to be disturbed, thousands of seals can at any time be seen basking in the sun.

'A few insects were collected, including beetles, butterflies, moths and dragon-flies. As soon as time will permit, all the collections will be worked up.'

MAPS.

Mr. C. O. Senécal, who, on July 1, succeeded Mr. James White as geographer and chief draughtsman, reports as follows on the mapping work :— Maps.

'During the past year, Mr. L. N. Richard has completed the compilation of the Nottaway River map; he also compiled the map of Ottawa City and vicinity, made corrections on the Dominion map and Manitoulin Island sheet from recent surveys, reduced a series of astronomical observations for the map of Hudson Strait, and attended to other work passing through the office.

'From January to August 6, Mr. W. J. Wilson has been employed on the map of the Dominion, and has traced a number of railway plans and profiles at the Department of Railways and Canals, and generally assisted Mr. J. White in the compilation of the altitudes of the country. He afterwards continued the compilation of Manitou sheet (sheet No. 4, Western Ontario), which is at present well advanced towards completion. On September 5, Mr. Wilson left for the field to assist Mr. R. Chalmers in the area covered by Andover sheet (sheet No. 2 S. W. New Brunswick) and returned to the office on November 10.

'Mr. J. F. E. Johnston has been engaged in the compilation of Grenville sheet (sheet No. 121, Ont. & Que.) which he almost completed before leaving on May 19, to assist Mr. R. G. McConnell in the

Maps—*Cont.* Klondike gold-field. Since his return, October 16, he has been engaged in plotting his field-work.

'Mr. O. E. Prud'homme has had, as in former years, charge of the stock of maps held for sale and distribution; he was employed on the compilation of the eastern sheet of the map of the Dominion, and in tracing various maps for the engraver. He has also made the pantograph reductions for the compilation of map of Hudson Strait, and a number of tracings and reductions for sheets Nos. 119, 120 and 122, Ont. and Que.

'Mr. A. Michaud was employed on the compilation of map-sheets of Nova Scotia and on general draughting work from June 14 to September 1. Mr. H. Taché has been employed since September 15. He has made several pantograph reductions for various maps in course of preparation, besides tracing a large number of township and other plans for office use. He also catalogued plans and maps from time to time. Mr. H. Lefebvre has been employed since December 18, and has drawn for zinc-etching reproduction, seven diagrams and three small maps of gas and oil areas in the counties of Essex, Lambton and Welland, Ontario.

'From January to July, my own time was spent in the compilation of the Mineral map of New Brunswick, drawing same for photolithography, in the compilation of part of map of the Rocky Mountains and in various compilations for the map of the Dominion. A tracing from photographic reduction of map of Basin of Nottaway River, was also made for the engraver.

'On July 1, I was appointed Geographer and Chief Draughtsman, and my time has since been spent in supervising the work generally, laying down projections for new maps, correcting and revising engraver's proofs of maps, preparing memoranda for the director, supplying information to the librarian and others, &c.

'What has been said by my predecessor, last year, with regard to the delay in the preparation of maps, may be repeated and emphasized here: "There is a congestion of mapping work in the office and one or two additional map-compilers are required to catch up with the work." New editions, revised to date, of several maps will probably soon be required, and considering the quantity of work already accumulated, slow progress will be unavoidable unless the staff of draughtsmen is increased.

'The western sheet of the Dominion map is almost completely engraved, a proof of the black having been received and corrected. Alterations from new surveys of Atlin Lake, Stikine River, Klondike

gold-field, &c., have been compiled and reduced and are nearly ready for the engraver. Maps—*Cont.*

'During the year, fourteen new maps, including the revised edition of the Sydney coal-field sheets have been published; twenty other maps and plans are in the engraver's hands. Of this number are sheets Nos. 42 to 48, 56 to 58, Nova Scotia, the publication of which is still deferred pending the determination of certain questions relating to geological classification. Forty-five other maps are completed or in various stages of compilation.

'An enumeration of the maps published during the year or in course of preparation is appended herewith :—

	Maps published.	Area in square miles.
604	British Columbia—Shuswap Sheet—Geology—Scale 4 miles to 1 inch.	6,400
669	" — " —Economic Minerals and Glacial Striæ—Scale 4 miles to 1 inch	6,400
664	Manitoba, Saskatchewan and Keewatin—Lake Winnipeg Sheet—Scale 8 miles to 1 inch	45,680
665	Quebec—North-west Sheet "Eastern Townships map"—Three Rivers Sheet—Scale 4 miles to 1 inch	7,200
667	Quebec—Gold Areas and Glacial Striæ of South-east Quebec—Scale 8 miles to 1 inch	12,160
668	Quebec—Map showing Graphite area near Buckingham—Scale 40 chains to 1 inch.	
634	Noova Scotia—Sheet No. 49—Musquodoboit Sheet—Scale 1 mile to 1 inch	216
652	Nova Scotia—Sheet No. 133—Cape Dauphin Sheet—Scale 1 mile to 1 inch	216
653	Nova Scotia—Sheet No. 134—Sydney Sheet—Scale 1 mile to 1 inch.	216
648	" —Mooseland Gold District—Scale 250 feet to 1 inch.	
650	" —Fifteen-mile Stream Gold District—Scale 500 feet to 1 inch.	
656	Nova Scotia—Upper Seal Harbour Gold District—Scale 500 feet to 1 inch.	
675	New Brunswick—Map of Principal Mineral Occurrences—Scale 10 miles to 1 inch	38,000
	Dominion of Canada—Scale 250 miles to 1 inch. (Index map for Paris Exhibition, 1900).	

Maps, engraving or in press.

	Dominion of Canada, 2 sheets, each 28″ x 34″, including the Dominion from the Atlantic to the Pacific Oceans and from International Boundary to Hudson Strait and Great Bear Lake—Scale 50 miles to 1 inch	3,500,000
677	Relief Map of Canada and the United States—Scale 250 miles to 1 inch.	
663	British Columbia—West Kootenay Sheet—Scale 4 miles to 1 inch	6,400
676	British Columbia and Alberta—Yellowhead Pass Route from Edmonton to Tête-Jaune Cache—Scale 8 miles to 1 inch.	
605	Ontario—Sheet No. 126—Manitoulin Island Sheet—Scale 4 miles to 1 inch	3,456
630	Ontario—Sheet No. 129—Mississagi Sheet—Scale 4 miles to 1 inch	3,456
626	" —Map showing the occurrences of iron ore, and other minerals in portions of the Counties of Frontenac, Lanark, Leeds and Renfrew—Scale 2 miles to 1 inch	1,700
681	Ontario—Sketch Map of Oil areas in Lambton County—Scale 4 miles to 1 inch.	
682	Ontario—Sketch Map of gas-field in Essex County—Scale 4 miles to 1 inch.	

Maps—*Cont.*

		Area in square miles.
683	Ontario—Sketch Map of gas-field in Welland County—Scale 4 miles to 1 inch.	
593	Nova Scotia—Sheet No. 42—Trafalgar Sheet—Scale 1 mile to 1 inch.	216
598	" — " 43—Stellarton " — " " .	216
600	" — " 44—New Glasgow Sheet—Scale 1 mile to 1 in.	216
608	" — " 45—Tony River " " " .	216
609	" — " 46—Pictou " " " .	216
610	" — " 47—Westville " " " .	216
633	" — " 48—Eastville " " " .	216
635	" — " 56—Shubenacadie " " " .	216
636	" — " 57—Truro " " " .	216
637	" — " 58—Earltown " " " .	216

Maps, compilation complete.

	Ontario and Quebec—Sheet No. 121—Grenville Sheet—Scale 4 miles to 1 inch	4,051
	Quebec—Basin of Nottaway River—Scale 10 miles to 1 inch	56,800
	Nova Scotia—Sheet No. 53—Lawrencetown Sheet—Scale 1 mile to 1 inch	216
666	Nova Scotia—Laurencetown Gold District—Scale 500 feet to 1 inch.	
	" " —Mount Uniacke Gold District—Scale 250 feet to 1 inch.	
	" " —Renfrew Gold District—Scale 500 feet to 1 inch.	
	" " —Waverly Gold District—Scale 250 feet to 1 inch.	

Maps in progress.

663	British Columbia—West Kootenay Sheet (partly engraved)—Scale 4 miles to 1 inch	6,400
	British Columbia—Map of Rocky Mountains—Scale 4 miles to 1 inch	
	Keewatin and Saskatchewan—Grass River Sheet—Scale 8 miles to 1 inch	
	Western Ontario—Sheet No. 4—Manitou Sheet—Scale 4 miles to 1 inch	3,456
	Ontario—Ottawa City and vicinity—Scale 1 mile to 1 inch.	
	" —Lake Nipigon map—Scale 4 miles to 1 inch.	
	" —Nipigon River map—Scale 1 mile to 1 inch.	
	" —Sheet No. 111—Brockville Sheet—Scale 4 miles to 1 inch	3,456
	" —Sheet No. 118—Haliburton Sheet—Scale 4 miles to 1 inch	3,456
	" —Sheet No. 119—Perth Sheet—Scale 4 miles to 1 inch	3,456
	" —Sheet No. 120—Ottawa Sheet—Scale 4 miles to 1 inch	4,224
	" —Sheet No. 122—Pembroke Sheet—Scale 4 miles to 1 inch	3,456
	Ungava and Franklin—Map of Hudson Strait—Scale 25 miles to 1 inch	16,800
	Ungava—Map of East Coast of Hudson Bay—Scale 25 miles to 1 inch.	16,800
	New Brunswick—Sheet No. 1 N.W.—Surface Geology—Scale 4 miles to 1 inch	3,456
	New Brunswick—Sheet, No. 2 S.W.—Surface Geology—Scale 4 miles to 1 inch	3,456
	Nova Scotia—Sheets Nos. 59 to 65, 76, 82, 100 and 101—Scale 1 mile to 1 inch	2,376
	" " —Sheets Nos. 54, 55, 66 to 69, 73—Scale 1 mile to 1 inch.	1,512
	" " —Catcha Gold District—Scale 250 feet to 1 inch.	
	" " —Montague " —Scale 250 feet to 1 inch.	
	" " —South Uniacke Gold District—Scale 250 feet to 1 inch.	
	" " —Tangier " —Scale 250 feet to 1 inch.	

Library.

The librarian, Dr. Thorburn, reports that during the year ended December 31, 1899, 8,137 copies of the Geological Survey publications were distributed, consisting of Annual Reports, special reports and maps; of these 6,735 were distributed in Canada, the remainder, 1,402 were sent to scientific, educational and literary institutions elsewhere. Library and publications.

There were received as exchanges 2,774 publications. These consist of reports, transactions, periodicals. pamphlets and maps.

The number of publications purchased during the year was 109. Periodicals subscribed for, 34.

The number of volumes bound has been 29.

The number of letters relating to library matters sent out was 1,012, besides acknowledgments for publications distributed, 678.

The number of letters relating to the library received was 1,466, and of acknowledgments, 767.

The number of publications sold during the year was 3,915, for which $559.06 was received.

There are now in the library about 13,000 volumes, in addition to a large number of pamphlets.

Note.—The books in the library can be consulted during office hours by any one wishing to obtain information on scientific subjects.

Visitors to Museum.

The number of visitors to the museum continues to show an annual increase, having been during the year 1899, 35,895. Visitors to museum.

Staff, Appropriations, Expenditure and Correspondence.

The strength of the staff at present employed is forty-eight. Changes in staff.

During the year the following changes have taken place:—

Mr. J. B. Tyrrell, resigned.

Mr. J. C. Gwillim, appointed assistant geologist.

Mr. James White, transferred to the Department of the Interior.

Mr. C. O. Senécal, appointed geographer *vice* Mr. J. White.

Appropriation and expenditure.

The funds available for the work and the expenditure of the department during the fiscal year ending June 30, 1899, were :—

——	Grant.	Expenditure.
	$ cts.	$ cts.
Civil list appropriation	52,650 00	
Geological Survey appropriation	55,429 39	
Boring appropriation	10,000 00	
Civil list salaries		50,564 60
Exploration and survey		24,277 14
Wages of temporary employees		12,830 65
Boring operations		7,516 02
Printing and lithography		13,695 24
Purchase of books and instruments		1,885 95
" chemical apparatus		213 34
" specimens		526 17
Stationery, mapping materials and Queen's Printer		1,354 23
Incidental and other expenses		1,495 31
Advances to explorers on account of 1899-1900		16,067 79
		130,426 44
Deduct—Paid in 1897-98 on account of 1898-99 $17,288.15		
Less—Transferred to casual revenue 371.72		
		16,916 43
		113,510 01
Unexpended balance civil list appropriation		2,085 40
" boring "		2,483 98
	118,079 39	118,079 39

The correspondence of the department shows a total of 9,625 letters sent, and 9,483 received.

I have the honour to be, sir,
Your obedient servant,

GEORGE M. DAWSON,
Deputy Head and Director.

Atlin Gold Field

PINE CREEK.

Methods of working on the larger streams.

GEOLOGICAL SURVEY OF CANADA
ROBERT BELL, M.D., D.Sc., LL.D., F.R.S.

REPORT

ON THE

ATLIN MINING DISTRICT

BRITISH COLUMBIA

BY

J. C. GWILLIM, B.Sc.

OTTAWA
PRINTED BY S. E. DAWSON, PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1901

No 743

To Robert Bell, M.D., LL.D., F.R.S.,
Director, Geological Survey of Canada.

Sir,—I have the honour to submit herewith a report upon the district containing the Atlin gold fields of northern British Columbia.

A contour map of this district compiled from surveys by Mr. W. H. Boyd and myself also accompanies this report.

In connection with the study of the geology of this district I wish to thank Dr. Hoffmann, Dr. Barlow and Dr. Ami of this survey for their assistance and Mr. O. E. Leroy of McGill University for microscopical examination of thin sections of rocks.

I have the honour to be,
Sir,
Your obedient servant,

J. C. GWILLIM.

Ottawa, May 15, 1901.

REPORT

ON THE

ATLIN MINING DISTRICT, BRITISH COLUMBIA

INTRODUCTION.

The examination and topographical survey of the Atlin district was undertaken in 1899, and two seasons were spent in gathering material for a 500-feet contour map geologically coloured, and a report upon the district. In 1900 I was assisted by Mr. W. H. Boyd who undertook the topography of the mountain features. The survey was tied on to Mr. Ogilvie's traverse of the Lewes River in 1887, at Tagish lake. Atlin district. Assistant.

The methods of survey were by means of boat-log traverses of the lakes and magnetic bearings, also latitude observations for the mountain and inland work. A transit triangulation was made by Mr. Boyd, of all the country between Taku arm and Teslin lake. Pack horses were used as carriers. Methods of survey.

Other sources of information have been through Messrs. Brownlee and Lowry of Atlin. Mr. A. St. Cyr, of Ottawa and many others resident in the district showed me courtesy for which I am much obliged. Acknowledgements.

HISTORY OF THE DISTRICT.

The district to which the following report applies, lies between latitudes 59° and 60° north and extends from longitude 132° to 134° 30′ west of Greenwich. This area includes the whole drainage basin of Atlin lake, together with the adjacent country to the east of it, draining into Teslin lake, also the Taku arm basin to the west of Atlin lake, in all some 6,000 square miles of the extreme north-west corner of British Columbia which has recently come into prominence as a placer gold producing district. Area included in report.

Preliminary map of district.

A preliminary map of the western portion of the district has been already published in the Summary Report for 1900. A more extensive contoured map accompanies the present report.

Gold discovered in 1898.

Atlin became known as a productive placer gold camp early in the year 1898 after the discoveries made by Miller and McLaren. These men approached the district from Skagway over the White Pass, thence by way of Tutshi lake and river and the Taku arm of Tagish lake to Atlin lake. Their first discovery of gold in paying quantities was made on Pine creek in January, 1898. This journey was made with dog sleds in the depth of winter. From this fact it appears probable that the district was known to be gold-bearing prior to their recorded discovery. Such a conclusion is supported by statements of miners and prospectors who winter along the Alaskan coast. There appears to be no evidence to prove that the creeks were formerly worked for gold, although this is commonly believed. A small amount of prospecting may have been done, but nothing more.

Indian inhabitants.

The presence and influence of Indian inhabitants is marked by portage trails from Tagish Houses to Little Atlin lake and Teslin river, also from Atlin lake at Pike river to the upper waters of Taku river and from Taku river to Teslin lake. Other evidences of a trail are found from Surprise lake to Teslin lake and also to Gladys lake. The intervening country appears to have been rarely visited, nor are the trails above mentioned important highways of Indian travel.

ACCESSIBILITY.

Routes followed by prospectors.

During the first rush into Atlin district in the spring of 1898 and 1899, many different routes were followed :—

The 'Fantail route' was a shorter winter trail for dog sleds from Skagway over White Pass. From White Pass the trail strikes southeasterly down a long wide depression leading to Fantail lake, thence across Taku arm to Atlin lake. The 'Taku route' was from Juneau up the Taku river and Nakina river to the mouth of Silver Salmon river, thence up the latter valley and over a low divide at Pike lake to Atlin lake.

Another all overland route was by way of the Telegraph-Teslin trail from Glenora to Teslin lake, thence across the ranges westward to Atlin lake. The present established route follows one of the early approaches by way of Taku arm from Tagish lake which is on the waterway to the Klondike. An all-rail and steamboat service now

connects the district with the Pacific coast at Skagway. This places it within a day's travel of the ocean steamers.

TOPOGRAPHY.

Topography. The general elevation of the lower lake and valley system comprising Lakes Bennett, Tagish, Taku arm and Atlin is about 2,200 feet above sea-level. The highest peaks of the district do not exceed 7,000 feet above sealevel. Generally speaking the mountain tops are from 5,000 to 6,500 feet above the sea. There is also a second system of depressions or upper valleys and plateaux which isolate the mountains into groups having a rounded and worn down appearance. The main lower lake system lies in depressions more or less in a north-and-south direction, following the general trend of range and valley as seen all through the more southern portions of British Columbia. These principal north-and-south valleys are connected by wide depressions.

Exploration not difficult. Contrasted with the rugged granitic barrier of the Coast Range the district offers easy exploration. The upper portions of the mountains above the timber line are grassy and open, without, as a rule, much obstruction to travelling. Extensive slopes and wide valleys are scantily timbered with Banksian pine, spruce and balsam.

Drainage. The drainage is in three directions. North and west to the Upper Yukon at Tagish lake by way of Taku arm; north and east to the Yukon by way of Teslin lake and river; and south-westerly by way of the Taku river to the Pacific ocean at Juneau. The central point of dispersion is from the rolling uplands half way between Atlin and Teslin lakes.

LAKES.

Important lakes. The chief lakes of this district are:— Taku arm, Atlin lake, and Teslin lake. These are the lakes of the great north-and-south valleys. Little Atlin lake is a shallow body of water 80 feet higher than Atlin lake, but in the same wide valley to the north of it. The lakes of the upper valleys which drain transversely east or west into these chief lakes are:— Gladys lake, Surprise lake, Tutshi lake, Fantail lake, Edgar lake and Nelson lake. Sloko lake drains south-easterly into Taku river and is the most southerly of these lakes.

Soundings taken. Concerning the depth, soundings were only taken along the northern half of Atlin lake. These soundings showed a fair regularity

in depth. The depth increasing gradually from 200 feet near the northern end to 550 feet opposite Atlin town. The deepest sounding made was 630 feet. Little Atlin lake, situated on the broad low divide between Atlin lake and Lake Marsh is a shallow body of water with low marshy western shores. Hall lake is an expansion of Gladys river between Gladys lake and Teslin lake. It has many islands and appears to be shallow also.

Little Atlin lake.

With the above two exceptions, the lakes of this district are deep, with mountain ranges rising directly from their shores. Small deltas exist at the mouths of the streams. Usually a broad low valley connects these lakes with other lakes at a higher or lower level. Sloko lake is almost entirely fed by glacial water; it is of a milky colour and quite opaque even in shallow places. This lake lies one mile south of Atlin lake at a level of 190 feet higher. A low divide, 120 feet higher than Sloko lake separates the waters flowing south-eastward to Taku river and these flowing north-westward to the Yukon.

Sloco lake.

PRINCIPAL RIVERS.

Principal rivers.

The chief streams of the district are Atlin river, Gladys river, Nakina river, Sloko river, Sucker river. Of these Gladys, Atlin and Sucker rivers are navigable for small boats and canoes. Pine creek, O'Donnel river, Pike river and Tulloch river are important streams draining into Atlin lake. Tutshi river, Otter river and Hale creek drain into Taku arm from the lakes above them which contain reservoirs of glacial water.

Effect of glaciers on streams.

The quantity of water in these streams depends upon their sources. In June and July the glacier-fed streams are low while the others are high. In August and September the reverse is the case. The same principle applies to the lakes. Atlin lake and river appear to be highest in early September. Teslin lake and Teslin river and all their tributaries have high water early in the summer.

Many creeks or brooks are lateral tributaries of these main streams and of the lakes. Atlin river drains Atlin lake into Taku arm. It is two miles long and falls thirty-eight feet. The current is swift and rough. Boast are poled or tracked up to it. Scows loaded with lumber are taken down this stream at high water. On June 18, 1899, the body of water was estimated at 80 feet wide, and 2 feet deep, with a current flowing at the rate of five miles an hour. On July 31, 1899, the body of water was estimated at 100 feet wide and six feet deep,

Atlin river.

Variation in volume.

with a current flowing at the rate of six miles an hour—nearly five times as great.

Gladys river drains Gladys lake and the district to the south and south-west. It is thirty-three miles long, falls about 700 feet and enters Teslin lake, fourteen miles south-east of Dawson Peaks. This is the largest river draining into Teslin lake from the west. Its volume on August 13, 1900, was estimated as sixty feet wide, two feet deep, with a current of four miles an hour. At that time the water was low since none of the sources are glacial. Strongly built boats can be taken up and down this stream. With the exception of Gladys falls, there is no serious obstacle to small boats. Gladys river.

The Nakina river runs in the district south-west of Calbreath post, at the southern end of Teslin lake. It flows rapidly through a roughly mountainous country along the southern edge of the Atlin district. The chief tributary from the north is the Silver Salmon river. Further to the west the Sloko river, a glacier fed stream of considerable volume and roughness joins the Nakina river. After this junction it becomes the Taku river, which enters the Pacific ocean near Juneau. Sail and row boats can be brought up the Taku river and the Indians appear to have long used it as a highway into the Teslin-Atlin country. It is also a fishing place for salmon as far up as the junction of the Silver Salmon river with the Nakina river and possibly further. An old Indian trail exists from this place to the southern end of Teslin lake, This trail has been replaced by the Taku trail of the miners, which is a rough and mountainous route. Nakina river. Taku river.

The Sucker river is the principal tributary of Gladys lake and river. It flows at an easy grade northwards along a remarkably straight and deep valley which is also the source of the Silver Salmon and of Ruth lake. The Sucker rriver has many tributaries, chief of which are Zenazie and Terra-heena creeks on the west and Rapid, Roy, Radnor and Brecon creeks on the east. Its length is twenty-nine miles and the fall in this distance about 200 feet. Sucker river. Tributaries of

Lubbock river is an exceedingly crooked stream which drains Little Atlin lake into Atlin lake proper at its northern end. This river is navigable for small boats ; its length is nine miles. The current is swift and without rapids. The fall is approximately eighty-one feet from Little Atlin lake to Atlin lake. The whole basin and course being a continuation northwards towards Lake Marsh of the Atlin lake depression or valley. The fall from Little Atlin lake to Lake Marsh is 115 feet. Lubbock river. Length and fall of.

Pike river.

Pike river flows into the southern portion of Atlin lake from the east. It had an estimated volume in July, twenty-five feet wide, two feet deep, and a current of three and a half miles an hour. Its length from Pike lake is eleven miles, but its source is in Simpson creek, among the Sloko mountains. This river flows in a great valley with a low divide at Pike lake which leads from Atlin lake to Silver Salmon and Taku rivers. It has been followed part of the way by the Dominion Telegraph line, and has been suggested as a possible all-rail route from Taku river to Atlin.

Possible all-rail route from Taku river to Atlin.

O'Donnel river rises in the high slopes and low mountains south of Surprise lake and drains into the southern part of Atlin lake, three miles north of Pike river. This stream is about thirty miles long. It is a rapid, shallow stream which has many tributaries draining a large district, nearly the whole of which is underlain by quartzites and limestones of Palæozoic age.

Pine creek.

Pine creek is the principal gold-bearing stream east of Atlin lake. It drains Surprise lake, and has a length of eleven miles with a fall of about 830 feet. There are many streams tributary to Surprise lake and Pine crek, the chief ones being Birch, Boulder and Ruby on the north; Wright, Otter and Spruce on the south. All these carry more or less placer gold. The valley of Pine creek is high and broad. It has many terraces. These are for the most part between 300 and 600 feet above the present level of Atlin lake.

Tributaries.

Water power of streams.

Concerning the volume and power of the various streams of this district, it is noticeable that there are but few falls, and these are of short descent. Nearly all the streams are rapid and at times torrential. The average fall of the larger streams is from 20 feet to 50 feet per mile, or less than one per cent. The fall of the gold-producing streams is greater. Pine creek falls 830 feet in eleven miles, in some portions of which the grade is four per cent.

The tributary mountain streams have a grade varying from 2·5 per cent to 7 per cent. The greatest volume of water occurs in June, as the result of the melting of the winter's snow. The only exceptions to this are the short glacier-fed rivers entering the southern part of Atlin lake and Taku Arm, which are in greatest volume in July and August. None of these streams receive appreciable freshets from summers or fall rains.

Greatest volume in June.

TERRACES.

Terraces.

Terraced deposits occur above the shores of Taku arm in the valley of Tutshi river. They are also found near Atlin lake, on Pine

creek, Fourth of July creek, Plateau creek and along the lower flanks of Mount Minto and Halcro peak. A very regular terrace runs parallel to the Lubbock river from Atlin lake to Little Atlin lake. The material which composes these terraces is usually fine sandy clay. There appears to be no general horizon at Tutshi river. There are terraces or benches at 10, 20, 40, 50, 80 and 240 feet at Taku arm. On Pine creek the principal terraces are between 200 and 500 feet above Atlin lake. Composition of.

Terraces, in places where they would naturally be found near the mouths of streams are commonly found up to a height of 400 feet above the general level of the Taku arm and Atlin lake. On Fourth-of-July creek well-defined terraces exist at a height of from 1,100 to 1,300 feet above Atlin laek. Such terraces appear to have been formed locally and to be confined to their own valleys or basins. Height of.

In many of the wide depressions which lead up to the sloping uplands of this district the terraced deposits give place to more irregular banks and ridges containing much the same material as the terraces. Such irregular deposits were seen on Pine, Spruce, Otter and McKee creeks to a height of 1,800 feet above Atlin lake and on Consolation creek, and the district about Gladys lake at somewhat lower levels.

CLIMATE, FAUNA AND FLORA.

The climate of this district is remarkable for its dryness. The summers of 1899 and 1900 were exceptionally wet in southern British Columbia, but the rainfall in the Atlin district during these seasons was very light. Climate.

The ice leaves Atlin lake about June 1, after which date night frosts are rare in the low-lying lake district. Cold, prevailing winds come inland from the south-west, over the snow-covered Coast Range. These winds are felt most along the greater valleys immediately east of the Coast Range. The weather in the valleys more inland is bright and warm until the end of September. On June 17, 1899, fresh snow fell on the hills to within 1,000 feet above Taku arm. On September 2 of the same year the first fall of snow covered the mountains above the timber line, but this did not remain. At the same date the first autumn frost, sufficient to kill tender vegetation, was observed in the Teslin valley near Calbreath post. Prevailing winds.

According to statements made concerning the winter climate, the following information has been gathered :—Atlin lake does not com- Snow fall.

pletely freeze over before January 1. About two to five feet of snow fall along the level of the main lakes. There is a greater fall in the mountains. The weather is moderately cold, bright and calm. A record of Fahrenheit temperatures was kept during the winter of 1898–99. A summary of these is given below :

Temperatures.

	Average.	Maximum.	Minimum.
	°	°	°
Last half November	6·0	40·0	18·0
First half December	28·0	44·0	18·0
Last half December	18·0	37·0	20·0
First half January	8·0	25·0	23·0
Last half January	7·0	31·0	22.0
First half February	17·0	46·9	32 0

The coldest periods correspond with those of the Kootenay district in the same year. The winter of 1900–01 was unusually severe, the same as in other parts of Canada.

The low-lying districts about the lake system of Taku arm, Atlin lake and Teslin lake do not appear to suffer much frost between June 1 and September 1. Garden vegetables of the hardier kinds will grow fairly well. There is not any great extent of fertile valley bottom in the Atlin district. Conditions appear somewhat more favourable in the great valley of Teslin lake where the rainfall is apparently greater and the soil less sandy.

Timber.

The forest growth is rather light. It is principally composed of the White spruce, *Picea alba*, Banksian pine, *Pinus Banksiana* and Balsam , *Abies balsamifera.* White spruce is found in damp valleys and on stream deltas. It is the only source of saw logs. Banksian pine clothes the dry valleys, low slopes and terraces up to 4000 feet above the sea in some places. Balsam fir occupies the rougher rocky ground near the timber line up to 5000 feet above the sea in a few places. Cottonwood occurs commonly at the mouths of streams. White poplar, *Populus tremuloides* is fairly common on flats and low hills. The mountain sides at and above the timber-line are often covered with a thick scrubby growth of dwarf birch *Betula gandulosa.* None of the pine, fir, tamarac, hemlock or cedar trees common to southern British Columbia were seen in the whole of this district. Birch was observed only on the eastern face of Taku mountains and at Nakina river, in small quantities.

Wild fruits

The native fruits, found most abundantly towards Teslin lake are : Raspberry, black and red currant, gooseberry and a dwarf cranberry *Vaccinium Vitis-Idæa.* Cranberry, muskegberry, amalanchior and blueberry are less abundant.

Seventy-nine species of plants were collected during the seasons of 1899 and 1900. These have been determined by Prof. Macoun. Some of them appear to be rare and possibly new to science.

Game and fur-bearing animals.

Animal life is somewhat scarce. Moose and caribou are not uncommon. There appears to be two species of mountain sheep; one being the recognized Rocky Mountain variety of the brownish colour and big horns, the other is lighter in colour. These are called Ibex by the hunters. The black bear is common. The silver tip or grizzly bear is also found. Marten is the chief fur.

Partridge and ptarmigan abundant.

Partridge and ptarmigan are very abundant. Wild ducks, geese and rabbits were occasionally seen. The common loon is the chief water bird of the deep lakes of the district. There are two species of ptarmigan. One appears to live during the summer altogether above the timber line on the bare mountain sides; this is the rock ptarmigan. It is smaller and grayer in colour than the other species, which spends the summer along the upper limit of the timber and brush. The favorite habitat of this second species is along the upper flats of the mountain streams amongst a low growth of willows and balsam fir.

GLACIATION.

Glaciation.

There are distinct evidences of glacial action on rock surfaces at the following places:—

Golden Gate, Taku arm, north shore;
Taku inlet, and islands of North bay;
Taku portage, south front of the hill 700 feet above the lake.

Half a mile south of Atlin town, on the east shore, and along the western face of Lina range to a height of 600 feet above the lake.

On the southern shore of Teresa island, along the sides of the narrow gaps leading from Atlin lake to the foot of the Llewellyn glacier.

The highest observed eroded rock-surface was on the southern end of the Le Roy range above Ptarmigan flats at a height of about 3,000 feet above Atlin lake or 5,200 feet above sea level. Glacial grooving and polishing was also observed on the limestone of Teslin valley near Calbreath post; eastwards of the divide between Atlin and Teslin lakes, there appears to have been a movement of the ice towards Teslin lake.

The characteristic granites of Surprise lake have been disintegrated and transported north eastward, forming the great slopes and banks of drift about Gladys lake and Consolation creek. A similar movement

appears to have taken place thirty-five miles to the south-eastward, whereby the peculiar hornblendic granite of the mountains west of Hurricane river has been transported across the Le Roy range and Ptarmigan flats to Fisher lake. There was no observed occurrence in situ of this hornblendic granite, east of the Hurricane river. The granite blocks and boulders now scattered over the Le Roy range are separated from the apparent source of supply by a valley over 1,500 feet deep and seven mile across.

Transported granite boulders.

In the drainage basin of Atlin lake itself, there are few evidences of glaciation over a level of 2,000 feet above the lake. Foreign boulders are only occasionally met with, but these are well rounded and usually composed of an acidic or binary granite which, so far as observed, does not exist in the neighbourhood. There are also rounded pebbles of jasper above the 2,000 feet level. The presence of these boulders of totally different material upon peaks composed of porphoritic rocks may point to a regional glaciation. Mount Minto rises directly from Atlin lake and the surrounding flats to a height of 4,650 feet above the lake. Its flanks are composed of a hornblende-biotite-granite. The upper 1,500 feet is a hornblende-porphyrite. Pebbles and boulders of this acidic granite and jasper, very well rounded, are seen right up to the peak. This peak is one of the highest in the district.

Mount Minto.

The tributary valleys which lead up from the great north-and-south lake system into the sloping uplands of the mountains between Atlin and Teslin lakes, are often heavily terraced. Above a level of about 600 feet in Pine creek valley, these terraces give place to ridges and lumpy hills. These appear to be composed almost entirely of local rock material. There is an occasional granite boulder, such as is found on the slopes above. Otherwise it may be said the material is local and glacial. It contains areas of boulder-clay, false bedded gravels, boulders and sands, and rounded irregular ridges and hummocky hills forming a depth of several hundred feet in some places upon the valley bed-rock beneath. The oxidized gravels and bed-rock of a pre-glacial representative of Spruce creek may be seen beneath a burden of 100 to 200 feet of drift material from Prams point to Discovery claim.

Terraced valleys.

It seems probable that the glacial deposits of the present valleys and uplands belong to a period more modern than that of the possible regional action which included the highest peaks. Local glaciers of somewhat the same character as the present Coast Range glaciers may have filled these broad valleys, leaving the peaks isolated above the ice-fields as they are to-day on the great Llewellyn glacier south of Atlin lake.

Probable modern glacial deposits.

There is, however, little resemblance between the character of the deposits of the present glacier and the deposits of these creeks. The present glacier is discharging large quantities of boulders, gravel and sand from its various tongues into Atlin and Sloko lakes, but without building up terraces or terminal moraines to any great extent. The Llewellyn glacier rises as a great field of ice and snow from near the southern end of Atlin lake. The grade of ascent for the first 2000 feet in altitude is about 4°, after which it becomes more flat and snow-covered.

Llewellyn glacier.

Prospectors who state they have crossed this ice-field say it took them 9 days and that it stretches from near the Pacific coast at Taku river to Atlin lake, or about 60 miles. Isolated mountains rise from the great snow-field leaving wide stretches of snowy sky-line between them.

Extent of ice-field.

During summer the surface of the glacier near its front is hard, smooth and rounded, with occasional crevasses. Many surface streams of clear water run for considerable distances, then descend into crevasses. In places the ice is much split up and is impassible. This appears, to be due to uneven convexities of the floor beneath.

Great masses of rough blocks or rock boulders, pebbles and mud occur as wide medial moraines. This burden of unassorted rock matter gradually descends to the faces of the glacier tongues and is disposed of without leaving adequate terminal moraines. Lateral moraines occur at salient points of the mountains as high as fifty feet above the present surface of the ice. The medial moraines continue as dark sinuous lines far into the wide snow-covered gaps between the peaks.

Moraines.

The issuing streams appear to be in flood at the end of July. They carry much sand, which seems to be filling up the floors of the fiords by which they have entrance into Atlin lake and Sloko lake. There is usually an extensive flat studded with pebbles between the outlet of the river at the glacier front and its sandy entrance into the lakes. The majority of the pebbles and boulders are granite, greenstone, porphyry and quartz, their relative abundance being in the order given.

Issuing streams.

GENERAL GEOLOGY.

The principal geological formations of the Atlin district have been provisionally classified as follows, in natural sequence, the oldest first.

General geology of Atlin district.

Palæozoic.—A group of rocks containing some schistose varieties. A great mass of crystalline limestone. Wide areas of cherty quartzite, and some slates and magnesium rocks of local distribution, which are called in this report the *Gold Series.*

Mesozoic.—A wide distribution of sandstone and conglomerates, chiefly found about the shores of southern Taku and Atlin lakes. Also mountain masses of andesite and various porphyrites apparently related to the sandstones, which are pyroclastic porphyry and andesite tuffs.

Superficial Deposits.—Both pre-glacial and post-glacial also some volcanic deposits of more recent formation than the present valley system.

Concerning the rocks classed as Palæozoic it may be said that they have the characteristics given by Dr. Dawson to certain formations found under similar conditions in the more southern parts of British Columbia.*

Limestones probably of Carboniferous age.

The great exposures of limestone, forming mountain masses about Taku arm and Little Atlin lake are placed in the Carboniferous system The peculiar cherty quartzites are also found associated with these lime stones in other parts of the province and constitute one of the mem bers of the Cache Creek series of the Kamloops sheet.

The schists occur only as more or less narrow developments near the contact of these older rocks with the coast granites and their isolated representations further inland. The peculiar and local Gold series of slates and magnesian rocks, chiefly confined to the basin of Pine creek, is evidently older than the granites of the district.

Mesozoic rocks.

The Mesozoic rocks were nowhere seen in direct contact with the Palæozoic formations. Their origin is chiefly igneous and they often pass imperceptibly from a sedimentary and stratified form into the mountain masses of porphyrite and andesite. The few fossils found in some of the bedded sandstones appear to belong to the Jurassic period.

The district shows evidence of considerable volcanic activity and some great masses of granite have been formed since Palæozoic times. Fossil evidence is very scarce, so that more can be said of the characteristics of these rocks than of their age, excepting relatively. The valleys contain pre-glacial gravels in some instances. And in many of the higher depressions the drift is also widespread.

Rocks similar to Cache Creek group.

Palæozoic.—The great areas and mountain masses of cherty quartzite and crystalline limestone appear to have much resemblance to the

* Kamloops map sheet p. 47. Part B. Annual Report Vol. VII.

Cache Creek group of the southern interior of British Columbia. The limestone which appears to be conformable with the quartzite and to overlie it, contains Fusulinæ and has been placed in the Carboniferous.

The quartzite is never heavily bedded or sugar-grained. It wears into rounded hills and does not form very important ranges. There is a wide variation in the field aspect of these friable thinly bedded quartzites, from a flinty grayish-white appearance to an almost carbonaceous shale. Irregular patches and bands of a gray crystalline limestone occur in the less chert-like areas. The carbonaceous variety appears to constitute one of the gold-bearing rocks on Wright and other creeks, otherwise it is not of economical importance so far as at present prospected. A microscopic examination of the cherty variety from the O'Donnel river by Mr. O. E. LeRoy, of McGill University, gives the following characteristics :— Result of microscopic examination.

'A dark-gray flinty rock composed of crypto-crystalline quartz. Running through this fine-grained mass in all directions are small veins of quartz. These often anastomose or enlarge forming pockets of irregular or oval outline. The quartz is generally clear or stained with iron or carbonaceous pigment.'

This is classed as a pyroclastic rock, an acid tuff compacted by secondary silica and is called hälleflinta.

A microscopic section of the Wright creek variety which is more carbonaceous and shale-like in appearance gives as follows :—'Extremely fine-grained, almost crypto-crystalline groundmass consisting in great part of quartz with a subordinate amount of kaolin through which are seen many veins of quartz. Biotite in considerable amount is in rounded grains and is found all through the mass. Pleochroism is brown and light-yellow. A few grains of pale-green chlorite and yellowish-brown limonite were also noted.'

The distribution of this cherty quartzite, is very wide in the Atlin district between Atlin and Teslin lakes, Consolation creek, the basin of Gladys lake and river, Ptarmigan flats, Hurricane river, Rapid Roy creek and Sucker river. All drain slopes which are for the most part quartzitic. The wide uplands or Arctic moors about the head waters of Terra-heena and O'Donnel rivers are also quartzitic. The granites of Surprise lake, McMaster mountain and Boulder plains are in direct contact with this formation. A few intrusions of greenstone also cut through it about the head of O'Donnel river. Cherty quartzites.

Generally speaking these quartzites may be said to floor the whole of the district between Atlin and Teslin lakes excepting where the great areas of later granite have intruded. The small areas of the Gold Series being partly intrusive and of later origin have also disturbed the quartzite at such places as the Lina and Johnson range, and at Chikoida or Merlin mountains.

Mountains of crystalline limestone.

The limestones form conspicuous mountains to the south of Tagish lake and were observed and described in the Yukon report of 1887, by Dr. Dawson as occurring along the east shore of Lake Laberge. They are usually quite crystalline and form solid white mountain ranges on both sides of Taku arm for twenty-five miles southward from Tagish lake. A short distance south of Tutshi lake, on the eastern shore, there is a sharply defined contact with a shaly black rock followed by greenstone. This contact runs north-easterly probably up the wide valley of Tutshi river and south-easterly along the northern flanks of Taku mountains in the vicinity of Atlin lake. The limestone here dips 45° to the north-east. The chief development of this formation strikes off to the east across Little Atlin lake towards Teslin river. Another more or less continuous belt of limestone forms mountain ranges north of O'Donnel river in the Johnson range, thence south-eastwards to the junction of the Silver Salmon and Nakina rivers. It appears that this latter development is also part of the same formation.

Silicious stringers and patches are often present in the limestone, otherwise, with the exception of a few dykes near the southern contact with the greenstones on Taku arm, this limestone is not much diversified or broken up locally.

Fossils.

The only fossil remains collected were some obscure coral and crinoid forms. On the evidence of fusulinæ collected by Dr. Dawson these rocks are placed in the carboniferous, and together with the quartzites and some eruptives show a strong resemblance to the Cache Creek group of southern British Columbia.

THE GOLD SERIES.

Rocks of Gold Series.

Included in the term 'Gold Series' are the characteristic rock-masses which form the basins of the present productive gold-bearing creeks. The chief rocks of this series are certain magnesian forms; a later and partially devitrified greenstone; and two varieties of slate. The magnesian rocks are dunite (peridotite) magnesite and serpentine.

The slates are biotitc and actinolite. The age of these rocks is not known. It is probable that the slates are Palæozoic and related to the cherty quartzites. The magnesian rocks represent ancient volcanic intrusives. Some of them may be of Palæozoic age. They are now very much decomposed and altered from their original form and constitution. The greenstones are younger than the other members of the series. They appear to be later than the Surprise Lake granite which has disturbed and broken up these other members.

Ancient intrusives.

In the valley of Pine creek there arc numerous dykes and some small areas of diorite associated principally with serpentine and dunite. The diorite may be related in origin to the greenstones, the latter representing the rocks cooled at the surface. This group of rocks in itself, largely, if not entirely of igneous origin, has undergone much fissuring, and mineralization, due to the intrusion of later igneous masses, such as the granite of Surprise lake and the greenstones. There are strong, well-defined fissure veins crossing the actinolite slates and the greenstone. These contain quartz and the sulphides of iron, lead and copper, and are not, as far as observed, of high value in gold or silver. Some large irregular masses of a barren-looking quartz also occur, and another set of mineralized bands or veins which contain mixed quartz and magnesite with gold values therein.

Rocks of igneous origin.

In the magnesian members of the Gold Series there appears tc be a resemblance to the rocks of the 'Mooschide series' described by Mr. R. G. McConnel* in the Klondike district. The distribution of the Gold Series beyond the basin of Pine creek is very limited. The typical actinolite slates and magnesian varieties are found in a small area south of Gladys lake at Brown Dome and they also occur in patches on the western shore of Atlin lakc near Taku portage at the base of Atlin mountains, and on Taku inlet west of the Taku mountains. Serpentines and greenstones occur about McKee creek and to the south-east in the Chikoida or Merlin mountains.

The characteristic rocks of the Gold Series may be described as follows:—

Actinolite slates.—These occur principally to the north of Pine creek about the basins of Birch, Boulder and Ruby creeks. They are not apparent to the south of Pine creek. Their position appears to be close to the contact of the Gold Series with the granite and they lie between it and the dunite, serpentine, etc. The structure is more or

Actinolite slates.

* Summary Report Geol. Surv. Can., 1899, p. 19.

less banded but is never slatelike, the fracture or jointage giving angular blocks. Above the forks of Birch creek they have a well-defined east-and-west strike and dip to the south.

On Birch and Boulder creeks these rocks have supplied the coarse gold of the streams. They have some low grade mineral veins and outcrops of quartz, together with some patches of the peculiar granular and friable limestone characteristic of these rocks. A microscopic section of a specimen from Boulder creek is described as follows :—

Microscopic sections of.

'The greater part of the rock is made up of a mesh-work of tabular and acicular individuals of pale-green actinolite, between which are small grains of felspar. Included in this matrix are large and rather clear areas of irregular outline. Between crossed nicols these are seen to be made up of a mosaic of felspar grains, twinned according to the albite and pericline laws. The grains vary in size from those easily distinguishable to almost crypto-crystalline. The felspar is albite. A considerable amount of magnetite in small grains is associated with the actinolite and also as very small inclusions together with actinolite needles in the felspar areas.' Several sections of this actinolite slate give somewhat similar results. There is usually a fair amount of magnetite present and in some cases zoisite.

Dunite.

Dunite (*Peridotite*).—This is another very characteristic rock of the Gold Series. It has a sugar-grained texture and a greenish colour. The weathering is usually brown and rugged like a ferruginous dolomite, but is sometimes smooth and white like serpentine. It is an alteration product of peridotite and is usually more or less serpentinized.

Microscopic section described.

The following is a description of the thin section of the rock from Lina range. 'The constituents are olivine, serpentine, tremolite and magnetite.' This specimen is much altered, containing a large amount of the last three minerals. The olivine individuals remaining are clear and much cracked, the cracks being broadened and filled with light yellow or colourless fibrous serpentine. The magnetite occurs in strings of small grains along the border between the olivine and serpentine or in larger grains throughout the serpentine and tremolite. Tremolite occurs in considerable amount in radiate and sheaf-like aggregates. Its cleavage is well marked and a transverse parting is common.

DISTRIBUTION.

Distribution.

The dunite was observed only within the basin of Pine creek and on Brown Dome, south of Gladys lake. It occurs along the northern

flank of Lina mountains immediately to the south of Atlin town, also in Pine Creek valley associated with serpentine and magnesite. Following a general direction a little north of east, it skirts the southern flank of Munro mountains, thence eastward to Ruby creek near its mouth on the promontory overlooking Surprise lake between Boulder and Ruby creeks. It is also found to the northward along the basins of Boulder, Birch and Ruby creeks. At the head of Ruby creek it forms mountain masses but is here cut off by the Surprise Lake granites. It reappears twelve miles to the eastward on Brown Dome, and its brown-weathering gave the name to that mountain.

MAGNESITE.

Magnesite.

Brown-weathering outcrops of this rock occur along the shore of Atlin lake near the mouth of Pine creek, also on Taku inlet west of Taku mountains. It is met with in smaller areas about the head of McKee creek, also on the mountains between Ruby, Boulder and Birch creeks. This rock, when in large masses, is usually affected by the presence of numerous quartz veins and stringers of small size. It is also more or less impregnated with pyrites, as at the Anaconda group of claims near Atlin, where there is a band of this rock over 1,000 feet wide. This band lies between mixed dunite and serpentine which appear to be quite unaffected by any shattering or mineralization. Owing to the presence of gold values in the magnesite of the Anaconda claims some study has been made of its composition. An analysis made for Mr. Bromley of the Nimrod syndicate gives the following results :—

Mode of occurrence.

Analysis of.

Magnesia	21·70
Protoxide of iron	5·10
Carbonic acid	27·00
Silica	45·68
Combined water and loss	0·52
	100·00

Some of the quartz stringers stained apple-green assayed as follows :—

Copper	traces.
Nickel	15 per cent.
Gold	1 dwt. per ton of 2,240 lbs.

From a series of holes drilled across this wide exposure of magnesite, gold values were always found, some of the more oxidized portions being rich in gold. Beneath the surface oxidation the values are lower. There is an evident concentration in the upper oxidized portions. A green coloration usually present in these ferriferous magnesites is due to the chromiferous mica, fuchsite, not carbonate of nickel as is commonly believed. A purer ivory-like form of magnesite occurs as narrow bands or veins cutting rocks other than those of the Gold Series.

Serpentine.

Serpentine.—This rock forms a portion of the bed-rock of Pine creek from Stephen dyke up to Gold Run. It appears to be the result of the decomposition of the original olivine rocks, now represented by the different magnesian varieties of the Gold Series. Its colour varies from apple-green to almost black. A few thin seams ($\frac{1}{8}$ inch) of asbestos were observed in an occurrence of this serpentine in the Lina range. Patches of this rock occur at the head of Ruby creek, Brown Dome and on Slate creek and the Chikoida mountains, south-west of Atlin. In the Chikoida mountains, it is closely associated with greenstone of the same character as that of McKee and Spruce creeks. No occurrence of chromite or other mineralization or vein-structure was observed in the serpentine.

Greenstone.

Greenstone.—This is a light-green fresh-looking rock. It has a massive dense appearance, sometimes with visible crystal forms and sometimes showing a flow structure in hand specimens. The compact, tough nature of this rock has caused it to form a rounded rather smooth bed-rock on McKee and Spruce creeks. The principal boulders of the present stream-beds and also of the pre-glacial ones, are of this greenstone. Microscopically, this rock gives :

Microscopic description of.

'A base of brownish isotropic glass, altering to a radiating fibrous product, which, optically, resembles a zeolite, but which does not gelatinize on treatment with hydrocloric acid. 'Associated with this in small amount is calcite. Pyrite in fair amount is scattered throughout the glass in irregular grains, but the rhombic dodecahedron is quite a common form. 'This rock appears to be a highly altered glass, and was originally a lava flow.'

Distribution.

The distribution of this greenstone is chiefly to the south of Pine creek in the valleys of McKee and Spruce creeks. It also forms the prominent Spruce mountain, between Pine and Spruce creeks, and is seen along the Atlin lake shore, north of Atlin town. It forms a contact with the granite near Fourth-of-July creek and appears to be

a younger rock, since it penetrates this granite in the form of dykes along the contact.

Greenstone of the same character is found on the western shore opposite Fourth of July creek. Here it is also in contact with granite. Its most westerly exposure is on Taku arm, a few miles south of Tutshi river, near the contact with the Carboniferous limestone. This is, however, less fresh-looking in appearance and may be an older diabase, representing the Gold Series in that locality. Greenstone intrusions of the same age and origin as those of Spruce creek are found to pass through the quartzitic rocks at the head of Bull creek and eastern branch of O'Donnel river. These, under the microscope, are classed as decomposed porphyrites.

Biotite slates

Biotite schists.—These form the upper gold-bearing basins of Spruce, Otter and Wright creeks. On Spruce and Otter creeks they appear as ribbed or ribbon-like rocks, gray and flaggy, with bands of softer material, like carbonaceous shales. On Wright creek they are very soft and shaly, and also heavily mineralized with iron pyrites. It may be observed that these slates lie in contact with the Surprise Lake granites near Wright creek and in contact with the greenstone of Spruce creek and mountain. Otherwise they do not differ in field appearance from varieties of the quartzite group seen on the upper branches of O'Donnel river, on the tributaries of Sucker river and on Ptarmigan flats. Hence they are found for a distance of fifty miles eastwards, but without the influence of extensive igneous intrusions such as occur where they are at present found to be gold-bearing.

Contacts.

SANDSTONES, CONGLOMERATES, ETC.

Cache creek limestone.

For twenty-five miles southwards of Tagish lake the Carboniferous Cache Creek limestone is found on each side of Taku arm. The low broad valley of Tutshi river appears to be the southern limit of the limestone on the western side. Two miles further south, on the eastern shore, this limestone is succeeded by a narrow belt of greenstone and porphyrite. This belt of rocks extends in a north-westerly and south-easterly direction, and separates the limestone from the great area of sandstones, conglomerates and so-called argillites which form the shore and islands of southern Taku arm, excepting the western bay, which enters the Coast Range granites. These sandstones also extend in places across the mountains from Taku arm into Atlin lake. They surround the southern portion of

Sandstones.

Atlin lake, but are not seen to the north of the southern flanks of Atlin mountain on the west shore, or north of the great O'Donnel and Pike river valley, on the eastern shore of Atlin lake. They probably occur further to the south-east in the direction of the Nakina river.

The prevailing variety of this sandstone series is of a greenish-gray colour. It is usually in heavy beds. There are occasional bands of a darker and more argillaceous-looking material, also some thick deposits of thinly-bedded fine grained black and gray material. Conglomerates occur somewhat rarely. Such beds usually contain very coarse boulders, as large as three feet in diameter. These boulders are principally granite, with sometimes a considerable number consisting of crystalline limestone and porphyrite.

Good section of.

A very good section of this sandstone formation is found on the west side of Tory inlet on Atlin lake. An anticline occurs at this point. The northern slope of the beds forms the abrupt eastern face of Section mountain. This section shows over 5,000 feet of thickly bedded sandstone of the greenish-gray false-bedded variety inter-banded with some finer-grained beds of darker material. The upper portion of these beds is without conglomerate. The lower beds contain some narrow bands of which the boulders are usually small and consist principally of granite and porphyrites (hornblende and andesite porphyrite).

Rocks of pyroclastic origin.

From microscopic examination of several specimens of this series, they appear to be of pyroclastic origin. One of these from the southern part of Taku arm is termed a prophyry tuff, and its appearance under the microscope is thus described :—

Microscopic description of a porphyry Stuff.

'A fine grained rock made up principally of individuals of a rather clear glassy striated felspar, with a subordinate amount of milky quartz, in a dark-gray base. This base is crypto-crystalline and in comparatively small amount. The felspar individuals are closely crowded together. There are many good forms with the angles slightly rounded, but the principal form is the angular or sub-angular one. They are twinned according to the albite law, many having in addition the pericline twinning. A few felspar individuals are fresh, but the greater number are more or less turbid along the cleavage or twinning planes. The quartz occurs in clear angular or sub-angular grains with a few opaque inclusions. Strain shadows are common. A few individuals of a pale-brown biotite occur bent or twisted in between the felspar grains, the former is altering to a very pale-green

almost isotropic chlorite. Calcite occurs as grains in the base and also fills in cracks in it and in the felspars, due to infiltrating waters. In places it is stained by hydrated oxide of iron.' A small well-rounded pebble taken out of specimen 18 was also sliced and found to be like specimen 99, a hälleflinta.

Strike of sandstone

The general strike of the sandstones is south-easterly. They usually occupy the low-lying shores of the greater lakes, but occur on Birch mountains to a height of 3,000 feet above Atlin lake; and between Taku arm and Atlin lake they form mountain masses to a height of over 2,000 feet above the lakes. They are nowhere observed in direct contact with any rocks other than the porphyrite and granite porphyry mountain areas common about the southern portion of Atlin lake. The transition from these bedded porphyrite and andesite tuffs to the porphyrites, andesites and basalts of Cameron and McCallum mountains is indefinite. Usually a very fine-grained andesite tuff intervenes.

Anticlines.

The beds are inclined generally at low angles. An anticline appears to pass from Section creek across the southern part of Teresa island; thence across Griffith island to a place near Moose creek. Along the range south of Taku inlet, near Golden Gate, there are several great foldings of the strata forming truncated anticlines which have their axes in a south-easterly direction.

Fossils probably of Jurassic age.

A few fossil forms were found in some of the darker fine-grained beds of this series of rocks. These were obtained from the west shore of Tory inlet, the south-eastern shore of Teresa island, and the eastern shore of Atlin lake south of Griffith island. From field conditions and lithological resemblance, this series of rocks was at first believed to be Cretaceous in age. The examination of the few fossil forms appears to place them in the Jurassic. No evidence of the occurrence of coal was obtained. Organic remains of any kind are rare in these pyroclastic rocks. The following is a note on the specimens of fossils collected on Atlin lake during the season of 1900 and submitted to Dr. H. M. Ami for examination:

Examined microscopically by Dr. H. M. Ami.

'The fossils are preserved for the most part in a rather imperfect manner in a dark, at times streaky, gray, fine-grained calcareous rock, which, when examined in thin sections under the microscope reveals the structure of a porphyrite or andesite tuff * * * The fossils are for the most part fragmentary, and were no doubt rather difficult to obtain in the hard andesite and tufaceous strata, but they represent several small collections made in different portions of Atlin lake and possibly different horizons in the Mesozoic.

It is very difficult to state precisely what is the age of the strata from which the organic remains were obtained, both on account of the condition in which the fossils are themselves preserved and on account of the fact that the fauna represented is practically a new and hitherto unrecognized one in that portion of North America. * * *

Ammonites.

The presence of a few ammonites, which had the general outward appearance of *Arniotites* not unlike *A. Vancouverensis* seemed to indicate a similar horizon to that of the Triassic system of the Cordilleran belt, but as none of these ammonites show any of the sutures, it is impossible to state precisely in what section or division to place them.'

Examined by Dr. T. W. Stanton.

Some of the most typical of these fossils were sent to Dr. Timothy W. Stanton, of Washington. He found it difficult to determine the ammonites even generically since they showed no sutures. He says :

'These may possibly be Triassic, but I think it more probable that they are early Jurassic. They are certainly not as late as the Cretaceous. There seem to be three or four species and perhaps nearly as many genera of ammonites.

'There are also a smooth species of *Pecten*, and two or three other simple forms of Pelecypoda, but these are of types having a wide range and do not aid in close correlation.' Besides the three or four species of ammonites referred to by Dr. Stanton, in the collection, the following may be mentioned :

1. A smooth species of *Pecten*, probably belonging to the subgenus *Pseudamusium*, and apparently an undescribed form.
2. A small shell-like *Trigonodus*.
3. A bivalve like *Tancredia*.
4. A fragment apparently of a species of *Inoceramus*, with conspicuous rather regular raised concentric folds or lines of growth.
5. A number of branching fucoid-like and carbonaceous markings on slabs, appear to indicate the presence of algæ.

GRANITES.

Large granite areas.

There are several very large areas of granite in the district between Atlin and Teslin lakes. This granite appear to belong to the same period as that of the Coast Range granite. It is usually hornblendic, with variations in the quantity of biotite. Its greatest development

extends almost unbrokenly from Atlin lake to the flats west of Teslin lake, a distance of fifty miles. It forms the shores of the northern portion of Atlin lake; thence in an eastern direction it constitutes the high rugged ranges about Surprise lake and Zenazie creek. The great valley of Sucker river intervenes, and the granite reappears in the Snowdon range to the east of it.

Source of drift material.

About Surprise lake the granite is almost without bisilicates. It consists of quartz and felspar, which form an easily disintegrated rock. The *debris* of this granite has gone towards the formation of the heavily drift-covered slopes to the south and west of Gladys lake. The yellow pre-glacial gravel of Pine creek also contains much of it as a coarse sand. The granite of Zenazie creek and Snowdon mountains is more hornblendic in character. It will be noticed that the longer axis of this granite area is nearly east and west. The adjacent rocks are the regional quartzites, with the exception of the actinolite slate of the Gold Series in Pine creek basin. The granite is evidently younger than any of these rocks, with the exception of the greenstone and the scoria and basalt of Ruby creek. Twenty miles south of the Surprise Lake granite, there are two other great mountain masses of granite. These are again separated by the valley of the upper Silver Salmon river, which is a continuation of the Sucker River valley.

Palæozoic quartzite flanks these ranges on the north-east and west. The most easterly of these masses occupies the high Boulder plains between the Nakina river, Hurricane river and Ruth lake. It is a great barren Alpine upland, strewn with boulders and draining gently southward to the Nakina river. It is built of hornblende granite, often porphyritic. It resembles the granite of the White pass in the Coast Range.

McMaster mountain.

The western area forms McMaster mountain. It lies between the upper Silver Salmon and O'Donnel rivers. The texture of this granite is more even-grained, and made up of small crystals of hornblende, biotite, much felspar and a little quartz. It weathers into a very massive, smoothly rounded range unlike the Surprise Lake granites. Dykes, veins and all foreign intrusions, variations or segregations are noticeably absent in this granite. It appears to be barren, both in placer and in lode minerals.

PORPHYRITES, ANDESITES AND BASALTS.

Eruptives.

This group appears to be closely connected with the origin of the sandstones of which they may be the non-fragmental representatives. They form the Taku, Cameron, McCallum and Sloko mountains. Each of these groups of mountains is isolated from the other, excepting McCallum and Sloko, which are divided by a deep valley. The group lies in a nearly north-and-south direction, parallel to the Coast Ranges. Excepting these occurrences there is no further development of the same set of rocks in the Atlin district. It is probable that they represent one of the localities of later igneous activity just east of the Coast Range. Rocks of a somewhat similar character have been brought from the Nordenskjold and Nisling rivers north of this district.

Form high mountain ranges.

These eruptives, as a rule, form high-pointed or smoothly-curved mountain ranges, resulting from the material weathering into small fragments. Many very steep and symmetrical cirques occur. The smooth grassy mountain tops over 5,000 feet above the sea-level are favourite feeding grounds of the Rocky Mountain sheep. All these eruptive areas, with the exception of Cameron mountain, lie outside, or at the edge of the sandstone series. Cameron mountain is almost completely surrounded by the sandstones. The change from tufaceous fragmental rocks to the porphyrites and andesites of this mountain is gradual and indefinite.

Taku mountain.

Taku mountain forms a mass about 2,000 feet above the level of the lakes. The eastern portion is very flat-topped, giving a basaltic appearance. The structure of its rock is also prismoidal in places and microscopic sections show it to be a porphyrite. There are also large areas of a greenish-reddish augite-porphyrite, which is found more extensively along the low hills between Llewellyn glacier and Atlin lake.

The low hill on Taku portage and the rocks about the outlet of Atlin river are andesites. Fine-grained andesite tuffs occur in the cirques and banks of Cameron and McCallum mountains. In hand specimens this much resembles the banded basalt of Sloko mountain.

Augite phorphyrite.

On the southern portion of Copper island in Atlin lake there is an area of augite porphyrite, a dark-green rock which sometimes weathers down into a sand of augite crystals. This rock appears to carry seams along which native copper has been deposited. Such an occurrence is found at the 'Noel' claim on Copper island. Sloko lake lies entirely

within mountain ranges of eruptives of this period. The arrangement of the various flows has resulted in a tabular appearance, due principally to almost horizontal bands of a flinty dark-coloured basalt at different horizons.

Natural section on Glacier inlet.

On Glacier inlet, which leads through a fiord-like channel from Atlin lake to the Llewellyn glacier and Coast Range granites, a natural section shows the transition from the sandstones to the lake basin. Passing southwards down the east shore of this deep inlet, the rocks are seen to strike south-easterly, dipping from 50° to vertical to the north-east. The section is roughly as follows :

Gray-brown rather coarse hard-weathering sandstone, 1,800 feet.

Very regular thickly bedded greenish-gray sandstone, 5,000 feet.

Greenish-reddish stratified and somewhat twisted rock, 2,500 feet. (This is probably augite andesite.)

Yellowish-brown conglomerate, of which the principal boulders are acidic granite, greenstone and a dark porphyrite, 2,500 feet.

Greenish-reddish twisted augite-andesite strike SSE., dip 85° ENE. This appears to be conformable.

Composition of augite andesite.

Specimen 54.—Augite-andesite, Sloko inlet.

'A massive compact tough rock, dull green in colour with brown and reddish-brown patches. It consists of a large number of finely twinned phenocrysts of felspar and a few rounded augites in a base which is partly crystalline and partly glassy. The felspar occurs in both large and small individuals, many of which have good crystalline form. They are nearly all turbid from alteration. Products, yellowish epidote and greenish zoisite, the latter in considerable amount. The augite is colourless, in rounded grains and rather decomposed. Magnetite in considerable amount and some biotite is present. The base is not in large amount, but the transition from ordinary glass to cryptocrystalline base is well seen.'

GRANITE PORPHYRY.

Granite porphyry.

'This rock consists of large individuals of a finely twinned felspar in a micro-granitic groundmass composed of quartz with magnetite, hornblende, biotite, chlorite and felspar. This groundmass is principally quartz and felspar. There seems to have been a movement subsequent to the formation of the individual crystals of felspar, as

they all show strain shadows and many are broken, bent or cracked. Crenulate borders are common which would indicate a further growth, the new material being in optical continuity with the parent grain.'

Forms conspicious mountain peaks.

This rock forms the conspicious peaks of Birch, Atlin and Cathedral mountains, all three groups being isolated from one another and on the south-west side of Atlin lake. These are distinct intrusions, probably of somewhat later age than the sandstones and porphyrites. This granite porphyry breaks up into broad plates of a few inches thick. The weathering down on Atlin mountains has resulted in a great rock slide from a basin on the eastern face.

RECENT ERUPTIVES.

Recent eruptives

The most recently formed eruptive rocks of this district occur on the west side of Ruby creek and at the head of Volcanic creek, sixteen miles north-east of Atlin. These deposits, consisting of scoria and basalt, have partly filled in pre-existing valleys. No evidence of glacial action or presence of foreign boulders was seen on these areas. The eruptions have taken place near the contact of the actinolite slates with the Surprise lake granite. On the west side of Ruby creek a mountain slope of brown and black scoria terminates in a crater-like summit 2,000 feet above the valley and 6,360 feet above the sea. The crater-like depression at the summit of this conical pile of scoria and basalt is about 300 yards in diameter. The central depression is ten feet below the lowest gaps in the rugged rim which surrounds it and 170 feet below the river at its highest point.

Area of Ruby creek eruptive.

The valley of Ruby creek 2,000 feet below is floored with a gray basalt through which the present stream has cut a narrow cañon. The area of this eruptive rock is about four square miles. Another and similar but smaller area lies at the head of Volcanic creek, at the northern base of Mount Barham. There is evidence of a crater of which the built-up rim is scoria. A flow of basalt has crossed the head of the creek northward in the direction of the present drainage ; pieces of scoria were noticed amongst the broken-down material of Mount Barham. The area of this eruption is less than one square mile.

Sandstones and conglomerates.

The only cemented beds of later origin than the sandstone series was an occurrence of horizontally bedded sandstones and conglomerates, near the entrance to Sloko inlet, at the southern end of Atlin lake. These are soft friable sandstones of a brown colour, containing pebbles

of mica-schist and a peculiar quartzite not seen elsewhere except in the vicinity of the Coast Range and as loose material in the glacier moraines. Some cemented conglomerate of wholly local origin was also seen on the western face of McCallum mountains.

Specimens collected by Mr. A. Saint-Cyr.

Mr. A. Saint-Cyr, D.L.S., in the course of establishing the northern boundary of British Columbia, collected a set of specimens from the prevailing and characteristic exposures along the line, from Windy arm to Teslin lake.

Description of.

Specimen No. 13, from White-Fraser mountain, one mile east of Windy arm, is a dark cleaved rock, apparently a hornblende schist and probably allied to the iron-stained band of Palæozoic hornblende schists and quartzites seen on Lake Bennett and elsewhere, as occupying a position in contact with and east of the Coast granites.

No. 10, from Patterson mountain, 3·5 miles east of Windy arm. Three specimens, obsidian, jasper and a hornblende porphyry.

No. 9, from White mountains, six miles east of Windy arm. A light coloured fresh-looking greenstone with quartz and calcite stringers.

No. 11, from the same place, is a brown granular rock, a very much decomposed dyke rock. Both of these specimens belong to igneous intrusions in the main mass of the mountain, which is formed of the crystalline palæozoic limestone.

No. 8 is from Morin mountain, two miles west of Taku arm. This is a white plated rock of fine texture. It resembles a variety seen on Sloko inlet of Atlin lake, an acid tuff of the porphyrite and andesite series, so largely developed along the first belt east of the Coast Range granite. Other specimens of greenstone and crystalline limestone taken from the district between Taku arm and Windy arm, show north-western extension of rocks similar to some in the Atlin district. The limestones appear, however, to be more broken into by igneous rocks of the newer series of porphyrites, greenstones and basalts. The specimens taken along this boundary line between Atlin and Teslin lakes show that the granite of the northern part of Atlin lake gives place, on going eastward, to the regional cherty quartzites. These quartzites form the floor of the great sloping flats of this district until the western flanks of Dawson peaks are reached. On the western and southern flanks of Dawson peaks there are crystalline limestones. The Dawson peaks themselves are made up principally of eruptives, probably porphyrites, some of which are dark fine-grained rocks, resembling basalt. These isolated mountains are apparently not the

Other specimens.

Dawson peaks.

result of denudation, but of a volcanic uplift through the Palæozoic floor of limestone and quartzite.

PRE-GLACIAL GRAVELS.

Pre-glacial gravels.

These are yellow, much decomposed gravels, usually found beneath gravel and clay of a much darker appearance, and probably of glacial origin. Such gravels in the district are easily recognized. They are often of a deep yellow lustrous appearance. On being broken the fractures will be found to be also yellowish with oxide of iron. This will often decide between the genuine ancient gravels and the gravels which are simply coated with iron oxide from a spring or water course.

Such gravels exist in the broad valleys of Pine and Spruce creeks. They pass, at times, beneath 200 feet of drift or superficial material of more recent origin. This drift was spread over the old valley and streams completely burying them at one time, but since that time the drainage has again cut down to its former level through this overlying drift and at some points the new or post-glacial stream has followed very closely in the course of the older pre-glacial one, and has also rewashed its gravels and cut down to the old bed-rock.

Spruce creek yellow gravels.

On Spruce creek these yellow gravels, as part of a pre-glacial stream, were traced from Prouses tunnel at about 100 below Discovery claim up to the bed-rock of the south bench at Discovery. They also extend for a short distance up the western bank of Spruce creek above Discovery claim, but are soon lost sight of beneath the moraine material so plentifully represented at the upper portion of Spruce creek. From Prouses tunnel to Discovery claim, a distance of nearly two miles, the course of this old channel appears to have been almost straight in a course of 97° (magnetic.) The present stream is more crooked. It has cut down to the level of the old stream bed in places and, in its windings exposes the yellow gravels, first on one side, then on the other, but the greater portion of the yellow gravels appears to be on the western side of the present stream. Into this, many tunnels have been driven, exposing a rather deep and wide deposit of the yellow gravel.

Gold contents of gravel from Prouses tunnel.

The gravel taken out of Prouses tunnel is said to have carried $6 to the cubic yard. At 93 below Discovery, on the eastern bank, active work and sluicing of these gravels was carried on during last summer Several men were preparing to drive tunnels into this deposit during the ensuing winter. The grade of the pre-glacial stream bed on

Atlin Gold Field

CLAIM 93, BELOW DISCOVERY, ON SPRUCE CREEK

Illustrating the pre-glacial gravels beneath glacial drift.

Spruce creek is somewhat steeper than that of the present stream. It is about 140 feet per mile. No evidence of pre-glacial gravels was seen lower than Prouses tunnel excepting some gravels stained with iron oxide, which may have been derived from the older channel near by.

Pine creek yellow gravels.

On Pine creek yellow gravels of a less conspicuous character were traced from Stephen dyke to the junction of Gold Run with Pine creek, a distance of about two miles. They appear to exist above this point on the north bank of Pine creek. Shafts sunk into the post-glacial channel of Gold Run, also pass through a brownish-white and yellow gravel, which is decomposed along lines of fracture. Much of the gravel here is of granitic origin, being derived from the Surprise Lake granites. Such gravels would not collect in the valley of Pine creek under present conditions. The present course of Pine creek from Gold Run down to Stephen dyke follows closely the course of the older stream, but appears to have cut somewhat deeper from Willow creek down to Stephen dyke.

Gravel of granitic origin.

Between Gold Run and Willow creek the yellow gravels occur on both the north and south banks at times together and sometimes as far as shown, on only one bank. Usually the ancient stream bed appears to have been quite wide, and some of the work done may be far from the chief channel of gold concentration. The fall in the present stream and that of the older one appears to have been about the same, for nearly a mile below Gold Run. About Willow creek it has been cut down more deeply, leaving a little rocky ridge between Willow and Pine creeks, which ridge appears to have been either bed-rock or rim-rock of the yellow gravel. This bench, twenty feet above the channel of Pine creek, and nearly as much above the earlier channel, Willow creek, has a whitish-yellow rock surface, with a thin deposit of yellow gravel and boulders, containing some gold. Below Willow creek the somewhat oxidized rocky benches down as far as Stephen dyke, are at present the only evidence of the older channel. There is also a deposit of yellow gravel in the south bank, opposite Pine town. Below the junction of Pine and Willow creeks it seems probable that most of the yellow gravel has been re-washed and its gold contents re-concentrated in the present stream-bed, which is fairly rich along this portion.

Evidence of older channel.

In the case of the Pine creek yellow gravels, there is at present no indication of glacial deposits overlying them. The very deep drift-deposits of Spruce Creek valley are absent in the upper valley of Pine creek. Boulder clay occurs at Willow creek and between Willow creek

Moranic ridges.

and Stephen Dyke creek, also morainic ridges, but not overlying the ancient stream deposits, so far as observed by the writer. There is some evidence to show that ice action may have cleared or kept clear this upper portion of Pine creek. The tracing of these ancient stream gravels of Pine and Spruce creeks depends almost entirely upon work done in shafts, excavations and tunnels, which have exposed the conspicuously coloured gravels.

Concentration of gold in pre-glacial streams.

The present surface of these valleys, covered with drift and terrace-deposits, affords little information concerning the courses of pre-glacial streams. Hence these deposits have been found along those portions of the present streams which have been most actively developed. What may exist above or below those limits of present exposure is more or less conjectural. It appears largely due to this coincidence of the past and present streams that pay-gravel is found along such portions. Where such is not the case, the yellow gravels may be found intact and in a different channel, but such a condition of things will not be revealed by surface indications to any great extent.

Neither Pine or Spruce creek yellow gravels were seen at a lower level than about 500 feet above Atlin lake. Their existence above Gold Run, on Pine and Discovery claim on Spruce creek is probable, but it is also not unlikely that portions of them have been removed by the local glacial action. On the upper part of Pine creek the deposit is wide and almost level, as far as observed. Such a condition affects the concentration of the gold into pay-channels. It is evident that the drainage conditions of pre-glacial times was much the same as at present. How much the upper valleys have been affected by the ice and the lower portions by the lake system, is not apparent.

ORIGIN AND OUTPUT OF PLACER GOLD.

Production of placer gold.

The placer gold production of the years 1898-99 and 1900 since the discovery of this district, has been practically confined to the basin of Pine creek and McKee creek, seven miles southward. The basins of these producing creeks lie within an area of rocks which have been given the name 'Gold Series', on account of their association with the gold-bearing gravels. The superficial material which now covers the broad valleys of Pine and Spruce creeks, whether the result of pre-glacial, glacial or post-glacial action, is almost entirely of local origin. The narrower V-shaped tributaries of Pine creek contain practically nothing but the ordinary mountain slope, débris or wash, and a stream-bed of coarse boulders of local origin.

It follows from these conditions that the gold concentrated along these past and present watercourses is also of local origin, whether derived from the veins, stringers or the more or less mineralized country-rock. There are many strong veins of quartz mineralized with the sulphides of iron, lead and copper within these basins. Some also contain free gold, but none of exceptional richness were observed. Some bands of rock, such as the wide magnesite exposure of the 'Anaconda' group, are found to be traversed by innumerable stringers of quartz and calcite. The whole mass of the rock carries small values in gold.

Gold of local origin.

The biotite slates of Wright creek are in places much impregnated with iron-pyrites and show other evidences of mineralization, while microscopic sections of all these rocks of the Gold Series show the presence of magnetite and pyrite. It seems therefore probable that the gold has been derived originally from the wearing away of great masses of the country-rock together with its contained veins and mineralized zones. The existence of a rich and extensive 'mother lode', workable as a quartz or lode mine is unlikely.

Probably derived from wearing away of country-rock.

Within the valleys of Spruce and Pine creeks, very little has been done by the present post-glacial streams towards enlarging or cutting down of these valleys. These creeks have done little beyond re-washing and re-concentrating the gold already collected in the drift and pre-glacial channels. Any local richness in placer gold will be found to be due to the presence of earlier concentrations in pre-glacial gravels, or from the drift and post-glacial channels, into which the present stream has cut its way.

POST GLACIAL CHANNELS.

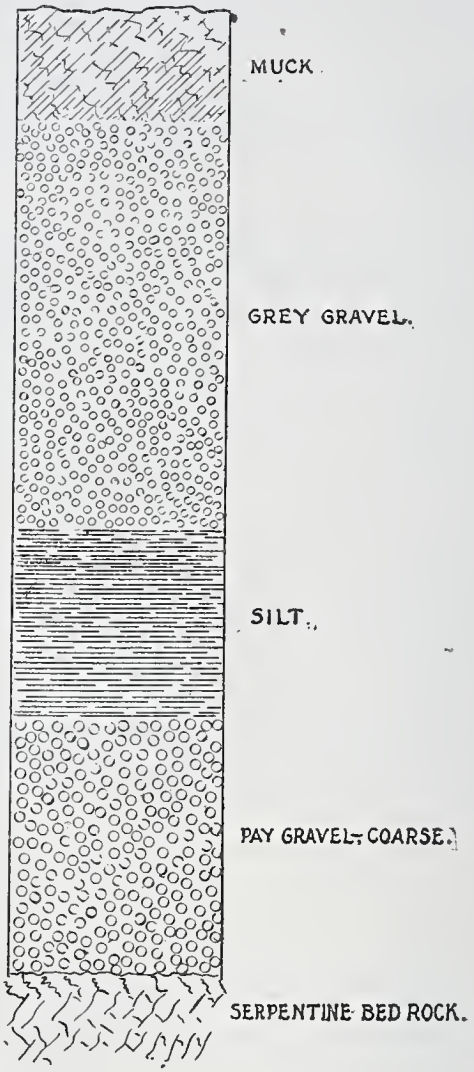
Post glacial channel.

Besides the present courses of Pine and Spruce creeks, there are other more or less regular and well-defined channels within these broad valleys. Some of these are shallow, flat-bottomed depressions, which appear to have been former courses of Pine creek. Such are Gold Run and Willow creek.

Thron gulch appears to have been an earlier course, not unlikely followed by a stream during the period at which the great terrace deposits were laid down. There is no evidence of a large volume of water having passed over this course for a long period of time. Several short feeders or low ravines lead into Pine creek from the south above Discovery claim. These are simply excavations in the drift made by small streams during freshets, but they appear to have

Gold Run creek.

concentrated some gold and to have enriched the Pine Creek gravels near the points of their junction with that stream. Gold Run creek is a low regular course about half a mile long on the south side of Pine



SECTION OF STREAM GRAVEL ON WILLOW CREEK
SCALE 3FT=1 INCH.

creek, one mile and a quarter above Pine city. This watercourse is separated from Pine creek by a low ridge of gabbro-diorite. Its surface is about fifteen feet above Pine creek. A shaft sunk to a depth of

thirty-five feet passes through a covering of dark muck, then into gray and finally yellowish-gray gravels, which are largely composed of granitic material, such as might be derived from the Surprise Lake granites. This gravel may be of pre-glacial origin. The depth to bed, or rim-rock on the 'Deadwood group,' indicates that a channel mor, deeply cut than Pine creek exists at this point. Gold values at this place are said to be good. As far as known there is no pay gravel due to the later stream which cuts the existing shallow channel. The fall in the ancient stream beneath Gold Run must have been very slight, certainly less than 1 per cent.

WILLOW CREEK.

Willow creek. This is a well-defined channel on the north side of Pine creek just above Pine city. Its length is about half a mile and it is separated from Pine creek by a low bench or ridge of serpentine, together with some dyke rocks of a dioritic character. This little ridge has a thin covering of yellow gravel, but no yellow gravel was seen in Willow creek itself. If such at any time existed it has been re-sorted and broken down into the material given in the following section, in ascending order.

Section.

Three and a half feet of coarse black and red-stained gravel on serpentine bed-rock.

Two and a half feet of fine silt or sand, sometimes stained brownish red.

Five and a half feet of mixed gray gravel.

One and a half feet of black surface muck.

Evidence of glacial action. The gravel below the silt on bed-rock carries the chief values. In this former stream-bed there is some evidence of glacial action, such as the pressure of some deposits of unassorted clay and boulders, and some striated boulders.

THRON GULCH.

Thron Gulch. This is not a gulch in the usual sense of the term, but a shallow fairly well-defined depression, sometimes constricted by rocky outcrops of serpentine between Pine city and Spruce junction. Between Spruce junction and the western end of Munro mountain it is a shallow wide depression, only a few feet lower than the surrounding terrace

flats. There are no rocky outcrops to be seen between Spruce junction and the gap at Munro mountain. After passing this gap, which is about 400 feet above the level of Atlin lake, a little stream has cut deeply into the terrace deposits and so continues this channel on to Fourth-of-July creek.

Bed-rock not reached.

Bed-rock, as far as known, has not been reached at any point between Spruce junction and Fourth-of-July creek. It is probable that deep deposits of terrace material overlie this portion. A shaft sunk in the gap near Munro mountain for about 50 feet shows a dark gravel rather even in size. Gravels of much the same character have been thrown up from pits sunk along the upper portion between Spruce junction and Pine city. There are said to be fair prospects from this development, but the prospecting of this stream or creek is not sufficient as yet.

No pre-glacial gravels seen.

No evidence of pre-glacial or yellow gravel deposits was seen along this course. They are not likely to occur, although it is a common supposition that Pine creek once followed this course in its way to Atlin lake. The fall from Pine city to Spruce junction, 1·5 miles, is about 150 feet. From Spruce junction to Munro mountain, 2·5 miles, it is about 100 feet; and from Munro mountain to Atlin lake 2·5 miles by way of the deeply cut little gulch and Fourth-of-July creek, the fall is 400 feet.

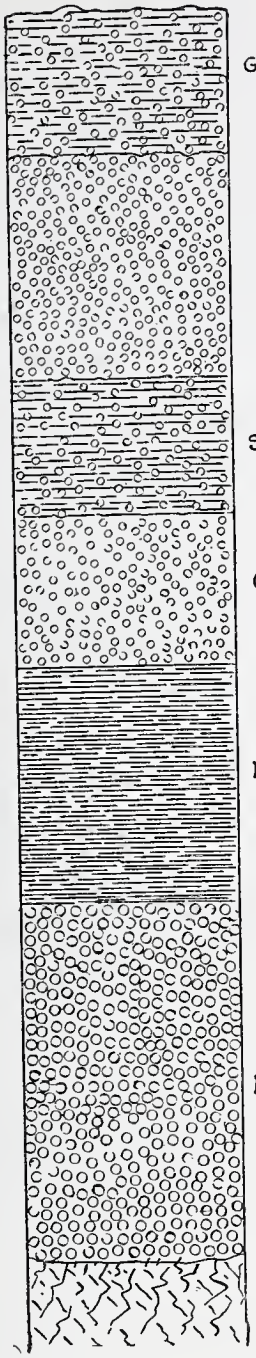
STEPHEN DYKE.

Stephen dyke.

The only important tributary from the south is Stephen Dyke creek, a small stream which heads in the morainic hills on the north side of Spruce creek. It has cut down or re-occupied a rather deep, narrow valley, at times between the moraines and drift, and at others between steep rocky walls of greenstone. A shaft sunk for 40 feet on this course has not reached bed-rock. The present stream seems inadequate to the formation of such a deep and narrow valley. No evidence of this being a pre-glacial channel of Spruce creek was observed. It is more likely to have been a temporary channel during the reunion of the local glacier at the head of Spruce creek, and as such has assisted in a concentration of placer gold. This also accounts for the presence of Spruce creek gold on the Stephen dyke benches.

Pine creek.

Pine creek, the principal gold-bearing stream of Atlin district, drains Surprise lake, eleven miles east of Atlin. For the first five miles after leaving Surprise lake it passes over a flat broad valley, with little exposure of rock along its course. The fall of the stream in this dis-



SECTION OF PINE CREEK GRAVELS AT DISCOVERY CLAIM

SCALE 3FT = 1 INCH.

tance is about 130 feet. The remaining six miles of its course is more rapid, with a fall of about 700 feet. It passes through several rocky cañons below Pine city and many terraced flats composed of more or less assorted material, also some deposits of stiff boulder-clay.

Varieties of bed-rock.

The principal varieties of bed-rock are diorite and serpentine, also some porphyrite and dyke material. The cañons at Halfway house and Stephen Dyke creek are a decomposed porphyrite and diorite. Below these cañons and above Pine city, serpentine is the prevailing bed-rock. The greater portion of the gold is moderately coarse, being about the size and shape of flax-seed. Nuggets up to a weight of several ounces are not uncommon. This gold is usually well-rounded or flattened; it occurs principally near bed-rock, usually in a rather coarse gravel, and is often somewhat stained with iron oxide.

Section at Discovery.

A section of the gravels at Discovery claim is as follows, in ascending order :—

5 feet, brown-red coarse gravels on serpentine bed-rock.
3 " brown-blue silt.
2 " gravel.
2 " silt and gravel.
3 " fine gravel.
2 " surface gray gravel, clay and muck.

On Harrigan's claim one face of the excavation shows 10 feet of very fine and even-grained bluish silt overlying about one foot of gray mixed gravel. This is the pay-gravel and lies on a serpentine bed-rock. Gold in paying quantities is also found on some of the thinly covered rocky benches 20 to 60 feet above the stream.

Placer mining on Pine creek.

Also on certain horizons, pay gravel is found by drifting into the banks on the south side of Pine creek below Discovery claim. These appear to be earlier post-glacial levels of Pine creek, before it had cut down to its present level. Placer mining on Pine creek during 1900 was practically confined to that portion which lies between Gold Run and Stephen dyke. The best results appear to have been obtained from the vicinity of Discovery claim and for about 30 claims below it.

The Sunrise Hydraulic Company has fitted up its appliances and commenced piping on the north bank of Pine creek, near the head of Willow creek. Bracketts Hydraulic Company has taken over much of Willow creek. During the season of 1900 they appear to have done effective and successful work.

pruce creek'

Spruce creek is the largest tributary of Pine creek. It rises thirteen miles to the south-east, and falls in its course to the junction with

Pine creek, some 1700 feet. The upper portion is simply a low grassy coulie leading over into Father creek and O'Donnel river. Low wide slopes and some local morainic material characterize the heads of this creek and also Otter and McKee creeks, all of which have their sources from the same wide uplands or Alpine moors. The upper seven miles of the stream flow through a flat-bottomed valley, between banks of drift material 75 to 100 feet high, and it falls in this distance about 400 feet.

Canon at Eagle point.

At Eagle point, two miles from the head, there is a little cañon formed by a barrier of rocks, which are a more quartzitic form of the biotite slates of Wright creek. At this place a few miners have been employed during the seasons of 1899–1900. Portions of the rocky bench, thinly covered with gravel, gave good returns in gold. Pay gravel is also being washed from the valley. This is not on bed-rock, but above a stratum of silt or clay, below which gold has been also found at some points.

Character of valley changes.

Seven miles from its head the character of the stream valley changes. It here enters a broad low barrier of greenstone, similar to that of McKee creek and Spruce mountain. The stream falls more rapidly through a series of deep cañons. Lower down, it cuts deeply into the drift, forming a ditch-like channel from 200 to 400 feet deep and 500 to 800 feet across from brink to brink of the banks. The material exposed by this deep cutting is a more or less assorted and false-bedded drift, with some deposits of stiff boulder-clay, containing striated boulders. There is little bed-rock exposed in all this upper portion. The yellow gravels are cut into here and there by the present stream, which falls about 1,300 feet in the lower six miles on a grade of from 2·5 to 3 per cent.

Drift and boulder-clay exposed in cutting.

Placer mining not general.

No hydraulic mining of importance has been carried on upon this creek. Placer mining has been active for the past two seasons on that portion of the creek from 138 below to 80 below Discovery, also at a few places higher up, and at the benches near Discovery claim, also at Eagle point. The greater portion of this stream, though proved to be gold-bearing at points widely apart, has not been worked by placer mining, on account of the depth to bed-rock. The supply of water is fully utilized at present by the placer miners for their water-wheels and sluices. The gold is usually coarse. Some nuggets, up to 40 ounces in weight, have been taken out. This gold runs somewhat finer than that of Pine creek.

Ruby creek.

Ruby creek lies fourteen and a half miles east of Atlin lake. It is the most easterly of the gold-bearing creeks, tributary to Pine creek,

from the north side. Its source, seven miles back from Surprise lake is from a number of remarkably deep, rather flat-bottomed valleys, which penetrate some of the diorite, actinolite slates and serpentine of the Gold Series. The valley downward from these upper tributaries has not an even grade. It has been filled in to some extent by a basalt flow, through which the present creek has cut a deep narrow cañon. From analogy with Birch and Boulder creeks, which also drain basins in rocks of the Gold Series, the middle portion of Ruby creek should have paying placers. This portion of the creek is overlain by the basalt. A mountain of scoria, evidently an old volcano, lies on the western range of this valley, and the Surprise granites occupy the eastern range near the mouth, but the upper portion has been deeply eroded in rocks of the Gold Series.

Middle portion should contain placer gold.

Boulder creek. Boulder creek is $12\frac{1}{2}$ miles east of Atlin and parallel to Ruby creek, Its length is about six miles. The sources are in steep ravines leading up into the granite ranges at its head. Granite is also found as bed-rock as far down the stream as Discovery claim. The valley of the creek is of the common V-shaped kind, and is heavily filled in with boulders. There is a fall of about 1,400 feet between the second forks and Surprise lake. The volume of water is sufficient for present needs.

Placer mining has been carried on with success during the seasons of 1899—1900. The gold is coarse. One nugget of 50 ounces was found on Discovery claim. Pay gravel is found above Discovery claim on a granite bed-rock, the only instance observed in the district. This may be accounted for by the fact that the upper portion of the valley was originally occupied by actinolite slates of the Gold Series. These have been worn down and the contained gold concentrated on the granite which underlies them. Upon the lower part of this stream The De Lamare Hydraulic Syndicate has a lease. A flume has been built and some piping done during the season of 1900. The upper portions of the productive ground being still in the hands of placer miners.

Pay gravel on granite bed-rock.

Birch creek is nine miles east of Atlin. It is parallel to Boulder creek and is much the same in form and character, with a smaller flow of water. Actinolite slates, together with some magnesite, dunite and limestone form the adjacent ranges. These rocks are traversed by some vein-filled fissures, and they also contain large bodies of a white barren looking quartz. This stream returned fair pay to placer miners during 1899. It has since been taken over almost entirely by the Atlin Lake Hydraulic Company, which has built a flume and begun operations near Discovery claim at the lower end of the creek.

Atlin lake hydraulic Company.

Atlin Gold Field

CLAIMS 2 AND 3, BELOW DISCOVERY, BOULDER CREEK.

Methods of working 100 foot claims.

Atlin Gold Field

CLAIM 37, ABOVE DISCOVERY, WRIGHT CREEK.

Illustrates shallow bed-rock and the mountains above timber line, about 4,500 ft. over sea level.

Ruby, Boulder and Birch creeks are the three chief northern tributaries of Pine creek. They are alike in physical features but differ from the other gold-bearing streams. They appear to be simply the V-shaped valleys and basins, due to water and snow erosion, and now contain no evidence of glacial origin or deposits.

Wright creek. Wright creek flows into Surprise lake from the south. It is the most easterly of the productive creeks south of Pine valley. The length of this stream is six and a half miles. Its sources are like those of Spruce and McKee creeks upon the Alpine uplands of this district. The upper portion is above timber line. The stream flows over a rather soft biotite slate which wears down without leaving boulders. It is this upper exposed portion of the stream bed which has so far proved productive. The gold values appear in some places to be found deep in the decomposed slate and in the banks at some distance from the stream. The rock is heavily impregnated with pyrites. Free mercury, cinnabar and native copper are said to be found also, but no certain evidence was obtained. The lower three miles of this valley are covered too deeply with drift to afford placer diggings. The Pendugwig Hydraulic Company has operated to some extent on this portion of the stream.

Gold found in biotite slates.

The quality and colour of the gold found on this stream are somewhat different from that of Pine creek and its northern tributaries. A more than usual amount of black sand and pyrites is concentrated along with the gold in washing. The slate of this creek resembles very much that seen in many places to the south-westward. At this point, however, it is in contact with the Surprise granites to the north, and may have derived some of its value from that circumstance.

Otter creek. Otter creek drains the slopes between Spruce and Wright creeks. It enters Pine creek close to its outlet from Surprise lake. Like Wright creek it rises in the great uplands 1,700 feet above Surprise lake. Its length is about ten miles. Six miles from the mouth there is a little cañon, much like the one at Eagle point on Spruce creek and in the same rocks. Placer mining has been successful at this point. Below this upper cañon the valley has a flat-bottomed, filled-in appearance and no productive work has yet been done. Near the mouth, there is another cañon, composed of quartzites, limestone and a talcose rock, containing large patches of a barren-looking quartz. This stream much resembles Spruce creek. It has the same drift deposits and little morainic hills. From the upper cañon to Pine creek there is a fall of about 900 feet, The volume of water is greater than that of Wright, Boulder or Birch creeks.

McKee creek.

McKee creek is the principal productive creek outside the drainage basin of Pine creek. It rises in the low slopes near the head of Spruce creek, seven miles east of Atlin lake, and empties into that lake seven miles south of Pine creek. The upper portion of its valley is deeply covered with drift, through which an occasional point of rock projects. From the upper flats the stream falls rapidly about 1,500 feet in a distance of four miles. The bed-rock consisting of a greenstone similar to that of Spruce creek is often exposed, on this portion of the creek which has been profitably worked from the junction of Little Eldorado down to Discovery. A bench or terrace of fine material lies along the north bank, otherwise the lower part of the valley resembles that of the creeks north of Pine creek.

Rock principally greenstones and quartzes.

The principal rocks found within the basin of McKee creek are the andesitic greenstones, some limestone and cherty quartzite. At the head of the valley there is some magnesite.

Hydraulic work by Nimrod Syndicate.

A fair supply of water and a good fall are points of advantage in this stream, which has now been producing for two seasons. The Nimrod Syndicate has purchased a large portion of the ground already worked and will operate thereon with hydraulic machinery.

Magnetic separator.

The production in placer gold of the Atlin district during the two seasons 1899 and 1900, amounted approximately to somewhat less than a million and a half dollars. Experiments and determinations made in connection with the black sand residues or concentrations of these creeks, show the efficiency of the Wetherill magnetic separator, and the presence of platinum and other metals of the same group.*

QUARTZ AND LODE MINING.

Lode mining not established.

Up to the present time not much has been done in establishing productive lode mining. Several mineral discoveries within the valley of Pine creek have been prospected and to some extent developed by the Nimrod Syndicate. These for different reasons are not now being actively worked. Some of the mineral deposits show signs of strength and probable permanence. The cost of development at present is heavy. Transportation rates added to this, make a heavy total for the production of refractory or smelting ores. Such ores are found to some extent in this district, more especially to the north of Pine valley in the actinolite slates, and in one instancein granite on Crater

Cost of production too great.

* Summary Report Geol. Surv. Can., 1900, p. 11

creek, a tributary of Fourth-of-July, there are veins of gold-bearing quartz. Some of these deposits are strong, well defined lodes, usually with a gangue of quartz. Sulphides of iron, lead and copper are present. As far as determined these are not of high enough value in the precious metals, to encourage their development during present conditions of heavy costs.

Free milling gold-quartz.

Other deposits of more or less free-milling gold-quartz offer better returns for development. In some cases very rich assays are given. The result of mill tests made by the Nimrod Syndicate people with their small five-stamp mill at Atlin go to show that general averages are moderately low. Mill tests of the Anaconda rock, an auriferous magnesite deposit of great extent, show it to be of too low grade in gold to pay under present conditions. A mill-run continued for several weeks upon the ore of the 'Paris Exhibition' on Munro peak gave, according to published report, a little over $10.00 per ton in gold. High values in gold are reported from the 'Ivy May', a quartz vein on the Tina mountains; also from the 'Yellow Jacket' which crosses Pine creek half a mile above Discovery claim. Some free gold and argentite were seen in the vein matter of the 'Lakeview' claim, near Surprise lake, and a solid but undefined deposit of galena and pyrites occurs on the 'Sunset,' at the summit between Keely and Consolation creeks.

High values reported.

'Little Edna' vein.

Near the head of the east fork of Birch creek there is a strong and regular vein, the 'Little Edna.' This is well mineralized with iron-pyrites and some chalcopyrite in a quartz gangue. This carries some values in gold and silver. Other veins and mineralized bodies are found principally within the rocks already defined as the Gold Series. It seems probable that some of these will become productive in time, especially those which are more or less free-milling. Under present conditions as to cost, ores of a smelting character will necessarily have to be of high grade. The presence of coking coal in this or some neighbouring district may, if discovered, cause an active development of the refractory ore bodies.

Discovery of coking coal needed.

The Engineer Mining Company is developing the 'Hope' claim on Taku arm, eight miles south of Golden Gate. The ore-body is composed of quartz and has an extensive outcrop at the lake shore It carries values in free gold, also some stibnite. Telluride of gold is said to be found but it was not detected in specimens examined in the laboratory of the Survey. The country-rock is a dark twisted slate, almost a shale in places. Quartz stringers and iron-pyrites are found throughout it. This is the only observed occurrence of precious metals

Native copper.

in the rocks of the Sandstone series. Some light coloured dykes occur in this locality. The occurrence of native copper was seen on the "Noel" claim near the southern shore of Copper island in the southern part of Atlin lake. At this place there is an occurrence of augite-porphyrite, a greenish coloured rock full of little crystals of pyroxene.

Mode of occurrence.

This rock has been fissured and along the fissure there is an occurrence of quartz and calcite as thin seams, together with some flakes and plates of native copper. On each side of this seam the country-rock is lightly impregnated with specks of native copper. The largest piece of copper taken from this place weighed about 40 pounds. Copper, both native and as a sulphide, appears to be common through this belt of rocks, which is a part of the porphyrite series not far from the contact with the sandstone.

WATER ANALYSIS.

Water analysis.

Samples of water were taken from three springs in the district and these were examined qualitatively in the laboratory of the Survey.

No. 1. Taken from a warm spring near the eastern shore of Atlin lake, ten miles south of Atlin. This water, when filtered was clear and bright, devoid of odour or any marked taste. Its total dissolved saline matter was 16·53 grains per imperial gallon. A qualitative analysis showed the presence of:

Soda, very small quantities;
Lime, small quantity;
Magnesia, very small quantity;
Sulphuric acid, very small quantity;
Carbonic acid, small quantity;
Chlorine, very small quantity;
Silica, trace;
Organic matter, trace.

Boiling produced a slight precipitate consisting of carbonate of lime with some carbonate of magnesia.

Spring lukewarm.

This spring is lukewarm. It has built up a raised channel and mound of calcareous sinter or tufa and appears to issue from near the contact of the O'Donnel River limestones with the quartzites. It was the only warm spring noted in the district.

Analysis of so-called 'soda-water'.

No. 2. An examination was also made of the so-called 'soda water' found issuing into the bed of McKee creek a little way above Discovery claim. It is described as a clear bright and colourless water, devoid

Atlin Gold Field

EAST OF ALTIN TOWNSITE.
Beds of hydro-magnesite deposited from mineral springs.

of odour or any marked taste. The total dissolved saline matter was 103 grains per imperial gallon. A qualitative analysis showed the presence of;

Soda, very small quantity;
Lime, rather small quantity;
Magnesia, rather small quantity;
Sulphuric acid, trace;
Carbonic acid, somewhat large quantity;
Chlorine, trace;
Silica, trace;
Organic matter, faint trace.

Boiling produced a rather small precipitate, consisting of carbonates of lime and magnesia.

This water, when fresh, is sharp and pleasant to the taste. There appears to be considerable free carbonic acid. The only deposit it leaves on the gravels is a stain of iron.

Examination of water from mineral spring at Atlin.

No. 3. A sample of water was collected from a mineral spring at the north end of the town of Atlin, in order to prove, if possible, the relation of such waters to the hydro-magnesite deposits in the vicinity. This water has been examined in the laboratory of the Survey, and is reported upon as follows by Dr. Hoffmann :—

This water was found to contain :

Potassa, traces.
Soda, very small quantity.
Lime, very small quantity.
Magnesia, somewhat large quantity.
Ferrous oxide, trace.
Sulphuric acid, very small quantity.
Carbonic acid, large quantity.
Chlorine, very small quantity.
Silica, trace.
Organic matter, faint traces.

Probable source of hydro-magnesite deposits.

The magnesia amounted approximately to 1·834 parts in 1,000, an amount which would correspond to 3·851 of magnesium carbonate, or 5·869 of magnesium bi-carbonate. It is more than probable that it is to the water of this and similar springs in the vicinity, that the deposits of hydro-magnesite, occurring near Atlin townsite, owe their origin. This spring is surrounded by a deposit of hydro-magnesite, with some iron oxide cementing this material. Along a

Description of beds.

shallow depression which passes immediately behind the town of Atlin, there are several patches of this white hydro-magnesite occurring as beds, raised to a height of some two or three feet above the surrounding flat or marsh. These are quite dry during the summer season, but in spring, it is said, springs issue all along this course. The total area of these deposits is some two or three acres, but the patches are isolated by the intervening marsh or bottom land, which has no trace of such material.

Pits sunk in beds.

Pits have been sunk in these beds for a few feet disclosing material which is described in the laboratory of the Survey as 'a pure white, more or less firmly compacted, yet readily friable mass of hydro-magnesite.'

Underlying rocks.

The rocks underlying this portion of Pine valley are magnesite serpentine and dunite, all magnesian rocks. These meet the granite near the western end of Munro peak. The deposits of hydro-magnesite occur to some extent along a line of depression leading nearly up to this contact-line at Lake Como.

MAP OF THE ATLIN DISTRICT.

Map of district.

In connection with the Atlin map it has been found difficult to define closely the many variations of rock formation. The age and sequence given is only provisional. Fossil remains are rare and the stratigraphical relations much disturbed. Excepting the limestones the principal formations appear to be of igneous, eruptive, or pyroclastic origin.

Geological boundaries difficult to define.

Very careful work and much time would be necessary to trace out all the geological boundaries, and the classification of the formations will depend upon further work in the districts to the south-east and north-west, where similar conditions are likely to prevail.

The present map indicates closely enough for present needs, the main features of the geology of the district.

GEOLOGICAL SURVEY OF CANADA
ROBERT BELL, M.D., D.Sc., LL.D., F.R.S., DIRECTOR

REPORT

ON THE

TOPOGRAPHY AND GEOLOGY

OF

GREAT BEAR LAKE

AND OF A

CHAIN OF LAKES AND STREAMS

THENCE TO

GREAT SLAVE LAKE

BY

J. MACINTOSH BELL, M.A.

OTTAWA
PRINTED BY S. E. DAWSON, PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1901

No. 725

Robert Bell, M.D., D.Sc., LL.D., F.R.S.

Director Geological Survey of Canada.

Sir,—I herewith beg to submit my report on the exploration during the seasons of 1899-1900, of Great Bear lake and of a chain of lakes and streams thence to Great Slave lake.

I have the honour to be, sir,

Your obedient servant,

J. MACINTOSH BELL.

Ottawa, April, 1901.

REPORT

ON THE

TOPOGRAPHY AND GEOLOGY OF GREAT BEAR LAKE

AND OF

A Chain of Lakes and Streams thence to Great Slave Lake.

By J. Macintosh Bell, M.A.,

1900.

District examined.

The following report is based on work which was carried out around Great Bear lake and through the country thence to Great Slave lake, under the direction of Dr. Robert Bell, in connection with his explorations during the seasons of 1899-1900. In the summer of 1899, I acted as Dr. Bell's assistant, and worked along the north-west arm of Great Slave lake and later along its north-eastern and south-eastern shores. When Dr. Bell started south in September, he thought it advisable to leave me in the country in order to continue operations during the winter and the following summer. Accordingly arrangements were made for me to pass the winter with Mr. F. C. Gaudet, of the Hudson's Bay Company. During the cold months, trips were undertaken east and west of Slave river and examinations were made of the Palæozoic rocks in these directions. I had hoped to be able to examine the country around the head-waters of the Buffalo river, but when I received instructions from Ottawa by the Hudson's Bay Company's packet, it was already too late in the season to do any exploring south of Great Slave lake, and I devoted all my efforts in preparing to make my trip to Great Bear lake a success. My instructions directed that I should undertake a topographical and geological survey not only of Great Bear lake itself, but of the Indian canoe-route between that lake and Great Slave lake, together with as much as possible of the adjoining country.

Continuance of work during winter.

Character of investigations.

Best route to Great Bear lake.

Having made careful inquiries from the Indians, as well as from other people cognizant of the facts, regarding the various routes to

Great Bear lake, I decided that the best way thither was by the Mackenzie and Bear rivers, returning from Great Bear lake via Lac Ste. Croix and Lac la Martre. It will be apparent that this plan was the more feasible when it is mentioned that no supplies whatever could be obtained at Fort Rae, while there was a chance of obtaining a fair supply from the Hudson's Bay Company at Fort Simpson.

Party leave Fort Resolution.

Accordingly I left Fort Resolution on April 11th with two canoemen, Charles Bunn and Louis Tremblay, and one dog team carrying my canoe and dunnage which was to go with us over Great Slave lake to Fort Providence. Another load with instruments and supplies had preceded us and we met the men and dogs returning while we were making the traverse of the lake. Unfortunately the condition of the snow upon the ice, owing to the mild weather, was such that we were able to travel only at night and even then with difficulty most of the time. The trip to Hay river that I had made in two days during the winter, now took us five. We did not reach Fort Providence till the 23rd. I may here take the opportunity of thanking the Rev. Mr. Marsh and the members of his mission for the hospitality which we received in passing through, and for the information he gave me concerning the northern country. I delayed at Fort Providence till the 28th, taking astronomical observations to compare with those made before at the same place by other observers.

Arrive at Fort Providence.

Willow river.

Leaving Fort Providence we proceeded to the mouth of the Willow river, some 16 miles below, where we decided to wait till the ice broke up. The season was already far advanced, the willows were in blossom and the river was now unsafe for traval, so that I knew it was useless to proceed further by dog team. Willow river was a convenient place because the Hudson's Bay Company's steamer Wrigley was drawn up there, and I had been advised to take passage in her as far as Fort Simpson on account of the danger due to the ice at this time of the year, and moreover there was abundance of both fish and wild fowl there, and the food question is always an important matter in the north.

Exploration of.

The ice on the Willow river broke up on the 6th of May and the Mackenzie on the 12th, but the Wrigley was unable to leave before the 21st. I therefore passed the intervening time in making short explorations up the Willow river. This stream, which joins the Mackenzie in latitude 61° 22′ 36″, is interesting as being the route followed by the Indians of the Mackenzie. Near its junction with the Mackenzie the river is over 300 yards broad, but there its current is comparatively slow, it soon dwindles, however, to a rapid stream of 15 yards in width, but with a strong volume of water. For the first six miles the country is low and swampy and the margins are covered with willow and alder, but

Description of country.

above this the banks reach 40 to 60 feet in height and the country in general becomes higher and better wooded. Exposures of till containing huge Archæan boulders and overlaid by sand and silt, are common. In places prairie-plateaux already green at the time of our visit, sloped away from the river. At a distance of ten miles up, the stream becomes swift and broken, and according to the Indians, it is almost a continuous rapid from this point to Willow lake, near Mont à la Corne, although in low water, tracking is said to be good and navigation not very difficult.

Arrive at Fort Simpson.

The Wrigley reached Fort Simpson on the 21st of May, and I remained here a week to make ready our outfit for the summer's trip and to obtain more information concerning the Bear Lake country. We set out from Fort Simpson on the 28th of May in our own canoe, the swift current of the Mackenzie so materially aiding our paddles that we reached Fort Wrigley in a day and a half. At Rocher-qui-trempe-à-l'eau, about 30 miles below this post, we halted for a few days on our journey in order to make a short trip into the interior. The rocks of this mountain have been so well described by Mr. McConnell of the Geological Survey, that it is unnecessary for me to elaborate his account.

Delayed at Fort Norman.

Arriving at Fort Norman on the 3rd of June, we learned that Bear Lake river had broken up only the day before and that Indians coming down from Great Bear lake announced that travelling there or on the river would be quite impossible for three weeks to come. Here, therefore, I again occupied myself in making short trips into the interior and by rearranging my plans and outfit.

Additional assistance employed.

At Fort Norman I engaged two more men, Charles Camsell and John Sanderson, the former agreeing to help me as much as possible in scientific work and the latter to act as guide and interpreter around Great Bear lake.

Bear river.

On the 21st of June, I left Fort Norman with my party of four and soon after entered the Bear river. At its mouth this stream is about 350 yards in width. Its clear waters join the Mackenzie through a deep wooded valley, which they have cut through the soft Tertiary strata. The deciduous trees were already in full leaf and the steeply sloping banks of the river were bright with hundreds of northern flowers. For the first 40 miles the physiography of the Bear river does not vary much. The banks are comparatively low, seldom exceeding 200 feet in height.

Timber.

They are well wooded with white spruce, canoe birch, aspen and balsam-poplar. Continual land slides on either side of the river, as a result of the eating away of the banks, have given the river-slopes a rough step-like appearance. The banks were at this time piled with ice to a height of twenty feet, sometimes stretch-

Trend of valley.

ing for miles along the shore. This made tracking especially difficult. The valley of the river for the first forty miles as far as the Egg islands, runs about 15° north of east and the river has a current of from three to four miles an hour. Its average width is over 200 yards. The high banks just described alternate with grassy swampy shores with scarcely any beach. The river was, however, very high and probably in low water gravel beaches are more or less common. At

Egg islands.

about forty-two miles above its mouth, the river widens to more than 400 yards to inclose the Egg islands, the largest of which is about one mile in length. These are alluvial islands, four in number, changing in size from year to year. At the time we passed they were completely covered with ice to a thickness of twenty and in places even thirty

Ice makes navigation difficult.

feet. Great pieces of ice kept breaking off from these masses causing huge waves to pass across the river, thus rendering navigation particularly difficult and we were often in danger of being swamped. Above the Egg islands, the upward course of the river soon enters that spur of the mountains which crosses the Mackenzie below Fort Simpson. Above this the rapidity of its current quickly increases,

Ascend Mount Charles.

culminating in the canyon of the Bear river. Just below the rapid in the canyon, Mount Charles rises to a height of 1,500 feet on the left side of the river. This is the highest peak of the mountains in this vicinity. I delayed for an afternoon to ascend it, in order to study the geology and to obtain a view of the surrounding country. In climbing the hill I was surprised at the size of the trees around its lower slope. White spruce of about twenty inches in diameter were quite common, as well as fine specimens of canoe-birch, balsam-poplar and aspen. The sunny slopes were gay with flowers, many of which one might expect

View from summit.

to find only in more southern latitudes. There was still a little snow on the summit, but for the most part, the hill was green and covered with shrubs. The view from the top was one of great beauty. Stretching to the horizon could be seen a wooded country thickly interspersed with lakes. Far away towards the south, Mount Clark stood out clear against the sky. It was connected with the mountain on which I stood by a line of low rugged limestone hills which continued on

Chain of lakes to the westward.

towards the north in the direction of the Mackenzie. To the westward lay the valley of the great Mackenzie, and nearer in the landscape was a chain of large lakes parallel to this stream, and having an outlet through the Willow river into the Bear river. A small deep river which drained the country to the northward could be seen to enter the Bear almost at the foot of Mount Charles. To the north-eastward was the deep depression of Great Bear lake. Continuing our way up the river, we soon entered the canyon with an easily navigable rapid,

but my men had some difficulty in tracking our canoes past it owing to the steepness of the banks. There is a portage on the north side which is used by the Indians, when the water is too high to permit of tracking along the shore. They also use it to carry part of the loads in order to lighten their canoes when heavily laden. For two or three miles (which is the length of the canyon) the banks of the river are very steep and from 150 to 200 feet in height. The river has here cut itself a deep channel through the soft cretaceous strata. Soon after passing above the rapid, the banks become sloping and less wooded. Cut-banks of sand and gravel were sometimes observed, but as a rule the shores were low and swampy.

Description of canyon.

We reached Great Bear lake on June 23rd and were disappointed to find that the ice on its surface was still intact, so that we were obliged to pitch our camp on the south side near the outlet. Here we waited till July 4th, when the lake was sufficiently clear of ice to allow us to proceed along the north shore. The country around the outlet is particularly dreary. It is an old camping ground of the Indians who gather here in winter for the fishing, which is good throughout the season, as the current is swift and the water remains open during the whole winter. The country hereabouts is quite destitute of trees, as they have all been used for fuel by the Indians. The low swampy shore-line continues to the southward in an immense muskeg which is said to stretch some twenty-five miles into the interior or towards the south-west.

Camp at Great Bear lake.

Several short trips were made into the interior along the south shore while we were waiting at the head of the river, but they failed to give much information either of topographical or geological interest. Some three or four miles along the south shore the trees reappear and continue as far as we could see. Shoals occur all along this shore and make it exceedingly difficult to obtain landing places.

Trips made into the interior.

While encamped at the head of the Bear river, we were visited by a band of Hareskin natives who came under the leadership of an Indian who at first appeared to be very unfriendly. He wanted to know whence we had come and what was our reason for being there. He said that he wished us to understand that we were to kill no caribou, as, if the white man went among them they would all surely disappear. However, after considerable exchange of conversation he realized that our intentions were friendly, and he became quite cordial, telling us where most of the caribou were to be found and where the best fishing places were, and, as a last consideration he agreed to meet us about the middle of August in MacTavish bay, and to send

Visited by Indians.

Engage one as guide.

one of his band to guide us thence southward to Great Slave lake.

Hareskin and Dogrib Indians.

The Hareskin and Dogrib Indians are, for the most part, a harmless and good natured race, living on the fish they catch or the deer they kill.' As a rule they travel at least once a year to trade with the Hudson's Bay Company either at Fort Rae or Fort Norman. They are, as yet, but little civilized, although the majority of them have recently been christianized by the Oblate fathers. They are rather a handsome people being tall and well built and their picturesque deer-skin coats, ornamented with beads and porcupine quills, give them a pleasing appearance.

Visit site of Fort Franklin.

Leaving our camp on the south side of the outlet we crossed to the site of Fort Franklin. The timber of this building had been used to warm the wigwams of the Indians and all that remained to mark its situation, were a few piles of stones where the fireplaces had been. At this place a small river enters the lake and is known to the Indians as Grey Goose river which flows from a lake of the same name, and other lakes farther to the north. Near these lakes, another river takes its rise and flows towards Smith bay. The canoe-route thus formed is used by the Indians in travelling from Smith bay to Keith bay, when the ice of Great Bear lake prevents them from following the lake shore. Keith bay, the most western part of Great Bear lake, stretches eastward towards Cape Etta and Gros Cap. The north-western shore of Keith bay is broken by two deep indentations. The most westerly I called Russel bay, and the other and deeper Richardson bay. Following the northern shore of Keith bay is a range of low sandy hills, never exceeding 500 feet in height. For the most part, these hills are at a distance of from three to four miles back from the lake shore, but in several places they touch the water's edge. Whiskeyjack hill is a rounded elevation near the shore, about thirteen miles from the head of the Bear river. The hills follow the immediate shore-line to the south-west of Richardson bay. The whole northern shore of Keith bay, including Russel and Richardson bays is low, but easy of approach. A fine sandy beach, replaced in some parts by gravel and boulders, is prolonged at the point in long narrow bars, sometimes of extraordinary shape and strewn with immense erratics. Two small rivers enter the foot of Russel bay. The most northerly, the Salatreil, a very small stream, has cut itself a deep winding channel through the great stretches of sand which occur there. Another river enters the western extremity of Richardson bay. We reached this point on July 12th, having been delayed several times by the ice and in each case I made short trips into the interior.

Canoe-route to Keith bay.

Physiography of country.

From Richardson bay we decided that it was best to follow an old Indian canoe-route commencing at the river above mentioned across the Gros Cap peninsula to Smith bay, rather than attempt to follow round the north shore of Richardson bay with the chance of being again delayed by the ice, which was still packed around Gros Cap. The western extremity of Richardson bay is low and swampy and the river which enters it has only a very slight current. We followed this up for about 2 miles and here it had dwindled to a small stream flowing from the north-west. At this distance, after searching for some time, we discovered a portage about half a mile long, which brought us into a small lake, less than three-quarters of a mile in length, from which a portage of a few hundred yards took us into a small muskeg lake. Having left the ice behind us at Richardson bay, I was astonished to find the lake filled with pond lilies, *Nuphar advena* (?), in flower, especially as this is rather a late summer flower about Ottawa. It is quite possible that it may have been *Nuphar polysephalum*, as the flower seemed rather too large for the other species. From this lake, a portage of 150 yards brought us into one of less than two miles in length, whence a portage of a quarter of a mile carried us into Lac des Maringuoins, a beautiful stretch of brown-coloured water about five miles in length by three miles in width. Its shores were well wooded with white spruce, willows and alders, but none of them of great size. Here I saw the most northern specimen of white birch on the north-west side of Great Bear lake. To the west of Lac des Maringuoins there is a short range of sandy hills.

Route from Richardson bay.

Lake filled with water lilies.

Lac des Maringouins.

Leaving this lake we entered a small river flowing from its northern end, which we followed till we arrived at Ice-bound bay, the most southern portion of Smith bay. It is not more than 8 or 9 miles in a straight line from Lac des Maringuoins to Ice-bound bay, but the river is shallow, rapid and exceedingly crooked, which gave us much trouble in navigating it. Its bed is often almost blocked by large Laurentian boulders, so large in fact that in several places I was almost convinced I had discovered an outcrop of these rocks in situ. In one part, the stream widens into a small lake, from which hundreds of ducks and other waterfowl rose as we passed along. The stream teemed with whitefish, passing up from the cold waters of Ice-bound bay to the warmer water of the inland lakes. Reaching Ice-bound bay on July 16th, we were surprised to find the bay filled with ice. A strong north wind kept the ice against the shore and prevented our moving until July 21st. We therefore fixed our camp in a good place in order to examine thoroughly the surrounding country.

Laurentian boulders.

Delayed by ice.

View from Knife hill.

A bluff of sand and sandstone overlaid with boulder clays, known as Knife hill, came to the water's edge at the north-west point of the bay. This hill is about 500 feet high and from its summit a splendid view was obtained, not only of the surrounding country, but also of the northern shore of Smith bay and the islands in the lake. To the south and south-west could be seen an elevated rolling sandy country, having small lakes with wooded shores in the valleys and becoming almost mountainous far away on the horizon. To the east lay the Sweet Grass hills, stretching off towards Gros Cap. Being high and having steep cut-banks of white sand, I supposed at first they might be partly covered with snow, but closer observation showed their true character. To the north lay high hills on the northern shore of Smith bay, which could be seen to rise higher farther away, and then to disappear in the north-western horizon. To the east and west lay the water of Smith bay, vanishing in either direction at the sky line. Westward its extent is much greater than hitherto supposed, but at the time of our visit this part of the lake was completely jammed with floating ice, so that we were unable to go into it at all.

Smith bay sighted.

Journey continued through ice.

When, at last, the wind changed on July 21st and allowed us to proceed, it was only by breaking our way through the ice for 4 miles that we were able to reach open water. From this point we were no more troubled with ice, and were glad to leave behind what had been so great an obstacle to our progress. A long traverse across an open stretch of water is always a dangerous undertaking, and my men did not like to risk the straight traverse to the north shore of Smith bay, which was nearly 18 miles. We preferred to go somewhat out of our way in order to pass by Treeless island which lay about half way across and almost directly north of Knife point and hill at a distance of about 7 miles. Treeless island is a low wind-swept spot of land, roughly triangular in shape, being about $2\frac{1}{2}$ miles long by $1\frac{1}{2}$ miles wide at its base. Its greatest height is about 100 feet and from this part of the island I was able to obtain good bearings along the southern shore of Smith bay. Treeless island thoroughly deserves its name. It is quite treeless but supports a few stunted specimens of willow brush *Salix glauca* and *S. speciosa*.

Treeless island.

Reach Smith bay.

A traverse of thirteen miles, in a direction a little east of north, brought us from Treeless island to the north shore of Smith bay near the mouth of a river which we ascended for two or three miles. I was unable to find out anything of interest about this stream, but it seems to have cut for itself a deep valley through the range of rounded wooded hills which lie to the north of this part of Smith bay, some

six or seven miles back from the shore. This is probably the Katseyedie river of Père Petitot's map, and if it is this stream, its source is in a large lake to the north called Petitot lake or Lac des Bois. We were delayed by wind and rain near its mouth, and I made several short excursions into the surrounding country. Between the hills and the lake is a low rolling tract with many ponds and muskegs. The low country is almost devoid of timber of any kind, and in fact from this point onward till we neared Fort Confidence we saw very few trees indeed, and these were small in the trunk and stunted in height. After leaving the Katseyedie river, the shores for some distance are sandy. Low battures extend out into the lake, sometimes completely separating stretches of water from the lake, and often being cut off from the mainland so as to form gravelly or sandy islands, the home of hundreds of gulls and wild fowl. Low uninteresting shores extend to within thirty miles of Fort Confidence. The beach is strewn with huge glacial erratics. Shoals are so common that landing places are found with difficulty and in many sections the shores are so flat and swampy that we could not get a camping place. The hills, which were mentioned before as being north of the mouth of the Katseyedie river, follow along the north shore of Dease bay for about fifty miles, when they gradually decrease in height and disappear. At the same time behind these hills, but at a distance of ten to fifteen miles back from the shore, a new range becomes prominent These are much higher and bolder in outline. They approach to within ten miles of the shore, about sixty miles east of the Katseyedie river and follow it for some six or seven miles, when they bend more to the north, and finally disappear against the horizon. It was a pleasing change from the cheerless, gravelly, treeless shores to reach Limestone point with its pronounced shore-line and with white spruce in the bay behind. Limestone point is about ninety miles east of the mouth of the Katseyedie river, and about thirty miles west of Fort Confidence. From this onward, the general appearance of the country becomes completely changed. High rocky banks following the immediate shore-line replace the swampy or gravelly shores which had prevailed for some distance.

Katseyedie river.

Timber scarce.

Erratics.

Prominent range of hills.

Natural features improve.

We reached old Fort Confidence on the last day of July and pitched our camp in order to make explorations into the country around. It was at this post that Sir John Richardson and Dr. Rae with Messrs. Dease and Simpson wintered in their search for Sir John Franklin in the middle of the century. We were surprised to find the log houses of the fort still in good condition, although nearly half a century had elapsed since their occupation, more especially as not even the chimneys

Fort Confidence.

Buildings still in good condition.

were standing of Fort Franklin at the head of the Bear river. Not a single nail had been used in the buildings at Fort Confidence, but skilful dove-tailing had given them both neatness and durability. The fort is situated in a sheltered place, protected by a big island. Its location is one of the few well-wooded spots on Great Bear lake and the trees are fine specimens, worthy of a more southern latitude. The ground had been free from snow for some weeks and *Papaver Arctica*, *Lupinus Arcticus*, and many other northern flowers, which mature quickly at this season of perpetual sunlight, brightened the mossy hillsides with colour. The park-like appearance of this far northern spot was indeed refreshing after the dreary country we had passed through since leaving the mouth of Bear river.

Flowers abundant.

Object of trip into Barren Land.

After having placed our provisions, etc., *en cache* on a small rocky island near the mouth of the Dease river, we started on August 1st on a trip into the Barren Land. Our object was to reach the Coppermine river, or at least to learn something of the geology and geography of the country intervening between it and Great Bear lake. Our trip lasted some 10 days, and before turning back we saw the waters of the Coppermine at a point which I supposed to be about 15 or 20 miles from its mouth. Our general course from the mouth of the Dease to the Coppermine was about 15° north of east, but often great deviations to either side were made to avoid high hills, lakes or other natural barriers. We followed the valley of the Dease for the first 35 miles and fording its two eastern branches crossed the height of land and reached the headwaters of the Happy river, a tributary of the Coppermine, from which we cut across country to the main stream.

Route followed.

Coppermine river reached.

Distance from Great Bear lake to Coppermine river.

Description of country.

The distance traversed between Great Bear lake and the Coppermine was approximately 60 miles, although it is very likely that in part of its course the Coppermine approaches somewhat nearer to Great Bear lake. For the first 15 miles the country is comparatively flat, thickly interspersed with lakes and well or fairly well wooded with spruce. Beyond this the region is a succession of hills and valleys with practically no timber. Willows, however, were seen at several favourable localities and fair-sized, though rather "scraggy" specimens of white spruce were observed on the Happy river. The Coppermine itself is said to be wooded to within 25 miles of its mouth. After crossing the Happy river, the country becomes almost mountainous; and boldly outlined and lofty hills rise in every direction. The hills seem to be grouped in ranges which run almost north and south. They are not of great altitude, the highest seldom reaching more than 800 feet above the plain below. The country is a particularly difficult one to pass over, the valleys are low and swampy and covered with

Difficulties of travel.

"têtes-de-femmes," and any one who has tried to walk through a country covered with these little hummocks will be able to appreciate our difficulties. You soon become tired out by endeavouring to step the unequal distances between these mounds of grass; you plunge violently and are at every few steps knee-deep in the ice-cold muck and sphagnum between them. Then after leaving the swampy valleys, the slopes were strewn with small angular bits of stone from the hills above, which was anything but a pleasing change when walking with wet and tired feet.

Coppermine river and tributary.

The Coppermine river, where we saw it, is a fine large stream with an even current of about 3 miles an hour, and over a quarter of a mile in width. Lofty rounded or mammillated hills rise on its opposite side and it seems to lose itself among similar hills in the direction of the sea. Its tributary, the Happy river, is not a large stream, and would be navigable for canoes with some difficulty, although I believe both the Indians and the Eskimos use it for navigation.

Dease river described.

The Dease river too is not of any considerable size, being less than 100 yards in breadth at its mouth. It is moreover exceedingly rapid and is not a feasible route for canoes passing up stream. It is formed by the union of two branches: the northerly, and larger branch, flowing from the north, while the south branch is formed by the union of two streams which drain the country to the south-west. The immediate valley of the main part of the Dease is rocky throughout its course. The country between it and the Coppermine is particularly dreary and desolate. It is thickly strewn with lakes some of which are of considerable size. Returning from the Coppermine, we sketched the shores of a large lake which I supposed to be the one aptly named by Sir John Richardson, Dismal lake. Certainly nothing could be more dismal than the wind-swept treeless shores of this northern lake in the heart of the Barren Lands and in a drizzling snow-storm, as was our experience when we visited it.

Return to Fort Confidence.

Party of Eskimos seen.

Near Dismal lake we fell in with a party of Eskimos who ran from us as we approached, in spite of all our efforts to retain them. They had evidently learned from their forefathers of the murderous treatment which their people had received from Herne and his followers when exploring the Coppermine and expected the same from us. But as a matter of fact, even had we been bloodthirstily inclined, we would have put up a poor fight, as we were all quite tired out. Their camp was a most extraordinary place and it would be hard to imagine a more uncomfortable situation. It lay almost on the shore of Dismal lake with a pond in the rear. A hillock was capped by three or four

Their camp.

huts. The walls were of flat stones placed on edge and the roofs were made of caribou skins. In the middle of the camp was a pile of raw caribou meat which the Eskimos are in the habit of laying by in the time of plenty. We waited some time at their camp, hoping they would return, but they did not do so. The caribou were grazing on the Barren Lands in vast herds and musk-oxen were also seen, so that there was no necessity for them to return to the food-supply at their camp. We were evidently the first white men they had seen, as not a single article of white man's manufacture was found in their camp.

Caribou plentiful.

Return journey commenced Aug. 13th.

We left Fort Confidence, near the mouth of the Dease, on August 13th, and started on our return journey along the southern shore of Dease bay. A large island, nearly 12 miles in length and covered with rocky hills, almost fills the north-east end of Dease bay. This island is known to the Indians as Nelu-wera-nelue. Good weather favoured us till we rounded Cape Macdonnel, the promontory between Dease and McTavish bays, which we reached on the 15th. For the first 30 miles, or as far as the Narakay islands, the southern shore of Dease bay is rough and rocky. Low broken hills follow the immediate shore and extend into the interior. Deep bays with wooded shores and small rocky islets are common.

Narakay islands.

Description of.

The Narakay islands themselves, of which there are seven or eight, are a prominent feature in the topography of this part of the lake. They are high and rocky and all present steep shores of greenstone to the water's edge. They lie about two miles off the mainland and can be seen distinctly for miles in either direction. After passing the Narakay islands, the country becomes low and swampy and assumes the uninteresting character of the north shore of the bay. The scenery shows great stretches of treeless tundra unbroken except for mounds of gravel or banks of sand. Low swampy islands with shallow pebbly shores lie off the gravel points, rendering navigation difficult near shore. It would be hard to imagine a more dreary landscape than that around Cape Macdonnel. The cape itself is a long narrow gravel point, strewn with immense Archæan boulders, stretching far out into the lake, and to the north-east and east are the dark and gloomy shores of Dease and MacTavish bays. The shore-line of MacTavish bay, east of Cape Macdonnel, is for the first fifty miles a repetition of the south shore of Dease bay, with the exception that perhaps the mainland is somewhat higher and better wooded. The approach to the shore is even more difficult than in Dease bay and the submerged beach extends fully 200 yards from the shore before dropping ten feet. Some forty-five miles east of Cape Macdonnel a good sized river enters, probably the Takaatcho

MacTavish and Dease bays.

River supposed to be the Takaatcho.

of Petitot, although it is rather difficult to correlate the two. Near its mouth we found great quantities of driftwood, among which were some good sized trunks. I was rather surprised to see these, but learned afterwards that in the interior the valley of this river is well wooded.

Soon after passing the mouth of the Takaatcho river, the country becomes rocky and hilly, and some ten miles beyond the river, the hills come to the water's edge. Among them is a steep angular knob of greenstone, called Black rock which rises to a height of 600 feet. It receives its name from the dark colour of the rock of which it is composed. The shore-line of MacTavish bay, which runs almost straight east from Cape MacDonnel, after passing Black rock turns to the north-east and north for about fifteen miles, whence it trends southward and south-westward to enclose Eda Travers bay, and from this bay onward the shore-line is much cut up and indented. Deep fiords run far into the interior of the country and narrow unexpected channels separate rocky islands from the mainland. The extreme south-eastern part of the lake is known as Klarondesh bay, a deep arm stretching towards the east-south-east and cut off from the main portion of MacTavish bay by a high rocky island, over 13 miles in length, called by the Indians Ndutcho island. The channels separating it from the mainland are so narrow that we at first doubted their existence and considered the western shore of the island to be the mainland east of MacTavish bay.

Trend of shore-line MacTavish bay.

The whole eastern shores of MacTavish bay, including Klarondesh bay and Eda Travers bay, is surrounded by high hills of granite and greenstone. For miles along some parts of the shore these hills rise almost perpendicularly from the water's edge to a height of 600 and 700 feet. Occasionally we had difficulty in finding a landing place, but as a rule, sheltered harbours were found in which the scenery was usually very fine. The high rocky walls were stained and weathered to beautiful shades of purple, red and brown, and gave, with the reflection of the precipitous cliffs in the clear northern waters, a singularly rich effect. I climbed several high hills along the eastern shore of Eda Travers bay and was able to get a good view of the country to the eastward. As far as the eye could reach stretched hill after hill, lake after lake, and forest after forest. On a large scale or in a general way the country would best be described as high, rough and broken. The hills were not associated in ranges, and the country has the general appearance of an elevated peneplain. Separate mountains are, as a rule, conical in shape, but often the greenstone hills ended

Hills of granite and greenstone.

Birdseye view of country.

abruptly in steep mural precipices, relieved by talus slopes. The highest hills at the shore do not exceed 800 feet in height, but they are probably higher in the interior. Around Klarondesh bay, the country is similar to that farther north although it is not so elevated.

Timber possibly of economic value.

All the eastern shore of MacTavish bay is wooded. In the valleys in the interior and around the bays and sheltered channels, this timber may be of economic importance. White spruce is the prevailing forest tree, although canoe-birch is found as far north as Eda Travers bay and is sufficiently large in Klarondesh bay to permit of its bark being used for making canoes. Tamarac and both balsam-poplar and aspen abound in Klarondesh bay, although they are not of any great size.

Reach mouth of Camsell river.

We reached the mouth of the Camsell river, which enters the southern part of Klarondesh bay, about eighteen miles east of the south end of Ndutcho island, on the 24th of August, which was the agreed place of rendezvous for the Indians, but we were disappointed to find that they had already left for their hunting grounds, and we had no prospect before us but to start across country without a guide through an unknown region, all the way to Great Slave lake.

Indian guide disappoints us.

It was too late in the year to attempt to follow around the shore of Great Bear lake and take the route across country by way of Lac le Martre, so we decided to attempt the one by Lac St. Croix which began with the Camsell river. This route was said to be the more difficult but the shorter of the two. The trip across country without a guide did not prove an easy one, and we often had great difficulty in getting along.

Trip across county to Great Slave lake difficult.

Camsell river.

The Camsell river has, at its mouth, a small island which divides the channel into two. The total width of the stream is about 100 yards. The current at the mouth is so strong that it may almost be termed a rapid, but it soon lessens, and at less than half a mile above the mouth, the river forms an expansion called Rainy lake. This lake which is only six miles in length is surrounded by low mammillated hills, which are wooded to the water's edge. At the eastern end of Rainy lake, the Camsell river enters with a short rapid, having a total drop of about four feet. It is ordinarily passed by a portage of a few steps on the eastern bank, but the water was too high and we were obliged to make a portage of about 100 yards on the opposite shore. Above this rapid the valley of the river turns abruptly to the north for about two miles and then it bends south. Just above this stretch is another short rapid, having a drop of five feet. Here there s a portage on the east bank, but it is used only in high water. Less

than half a mile above this is the White Eagle fall, the roar of which can be heard distinctly at Great Bear lake, on a calm day. White Eagle fall is more correctly a cascade of almost a quarter of a mile in length, the total drop being less than fifty feet. Here the river flows over syenite rocks. The scenery about the falls, with the blue hills rising in the background and the foaming river below is particularly pretty. White Eagle fall.

At the White Eagle fall, we were obliged to cut our own portage-road through the woods from the foot of the bay east of the falls to the slack water above. We had some difficulty in doing this, as the trees stood thickly together and were of considerable size. The portage is about 600 yards in length, partly over rough rocky ground and partly through a swamp. The country now ceased to be mountainous, but isolated rounded hills were to be seen on every side. Passing on up the river, we came to another chute about three miles south-east of White Eagle fall. Here the drop was about ten feet and the obstruction is passed by a portage of a few steps on the west bank. Soon after passing this rapid, we emerged upon a beautiful lake, which I supposed to be the Lac Clut of Père Petitot. It is not a large lake, being about six miles long by as many wide, and its area is greatly diminished by a large island which fills the centre of the lake. To the east of Lac Clut runs a low range of hills which continues on towards the south-west. Portage at White Eagle fall.

Leaving Lac Clut at a point towards its south-western extremity, a short stretch of river brought us into another lake, which I have named Lac Grouard. It is a narrow lake about sixteen miles in length, but its greatest breadth does not reach three miles. A few miles up it divides in two, one arm stretching towards the south and the other towards the south-west. So far our course had been easy, but here we were in a dilemma as to which way to go. I climbed the highest hills in the neighbourhood but could not see the valley of the river in either direction. After considerable discussion, we finally decided to follow the way towards the south-west and were disappointed on reaching its south-western extremity to find no river. Later we learned that the Camsell river enters the southern bay, but as a matter of fact the river is here seldom used by the Indians, as it is exceedingly rapid and chance really took us in the right direction, for after searching around for some time we discovered a trail leading to another lake, not a quarter of a mile distant from Lac Grouard. This lake, I at first took to be a small one, but afterwards found out that what I then considered to be the whole lake was in reality merely the most north- Lac Grouard. Route difficult to determine.

easterly bay of the largest lake on our course. It is much resorted to
Lake Hottah. by the Indians in winter and is named by them Lake Hottah (Two year old Moose lake). Lake Hottah is a magnificent stretch of beautiful clear water. Its maze of rocky tree-covered islands rivals those of the St. Lawrence in beauty. To the east and south-east conical hills rise to a height of 800 feet from a comparatively low level country and to the south-west runs a low range of mountains, which are said to stretch almost to MacVicar bay of Great Bear lake. Lake Hottah is about forty miles in length from north to south, and is in places over ten miles in width. It has its outlet from the north-western end, towards MacVicar bay and a large river draining the country to the
Islands make survey difficult. south-westward enters the lake on its western side. Its maze of islands made it exceedingly difficult to survey, and on account of the great width it was only by climbing hills that I was able to sketch in the contours of the western shore or the opposite one from that along which I was passing.

Lake Stairs. From the south-eastern extremity of Hottah Lake, a portage of 175 yards brought us into Lake Stairs, and we were again in the waters of the Camsell river, but unfortunately in passing along the lake we missed the river which flows into it and up which we intended to go, and before we knew of our mistake we were at the foot of the lake and there we found the river flowing out of it. A trip was made to a high hill in the interior and from it we discovered that the river flowed into the lake from a bay about half way down. We were, therefore, obliged to return that far. Lake Stairs is about nine miles in length and less than four miles in its greatest breadth. Entering the river from Lake Stairs, we found that it had diminished very much in volume since we had last seen it, being now little more than forty yards wide.
Beaver Lodge lake. Some three miles above Lake Stairs, it flows out of Beaver Lodge lake. This sheet of water has roughly the outline of a dumb-bell, having two large extremities and a narrow central portion. At the narrows are two conical hills in the form of a beaver's house and these give the lake its name. To the north of Beaver Lodge lake and between it and Lake Stairs runs a low ridge of rocky hills.

Lac Malfait. We left Beaver Lodge lake at its north-eastern extremity and after paddling a mile and a half against a sluggish current entered Lac Malfait, which has a most extraordinary form. Its shore-line is more broken than that of any other lake I have ever seen. Deep bays stretch in every direction and numerous islands with narrow channels between them divide the water into smaller lakes. Although it is really a small lake, we searched a whole afternoon in trying to find the

river which flows into it, but without success, and we afterwards learned that it enters the lake very near to its discharge. After we were almost in despair as to how we should get out of the lake, we discovered a portage of about half a mile long near the eastern end leading over a sandy moraine through a beautifully wooded tract to another lake, which stretched off towards the south. The latter, which I called Lake Isabella, is about seven miles in length. Towards its south-western end there is a ridge of low hills with even outline which seems to be a continuation of those seen south-west of Lake Hottah. These hills, from their form appear to consist of Palæozoic rocks, while all the hills to the eastward, judging from their rounded appearance, would seem to be of Archæan origin. Leaving Lake Isabella, we made three short portages with two small lakes between them, before we again reached a sheet of water of notable size.

Portage to Lake Isabella.

The first considerable lake we came to was the one I supposed, from its position, to be Lac Ste. Croix, mentioned by Père Petitot. It is a lake, so filled with islands and channels, that I was only able to obtain a rough idea of its size and to make a very indifferent track-survey of it. The Camsell River is said to flow from the northern end of this lake and to enter Lake Isabella near the portage, but we did not see it. Lac Ste. Croix is about sixteen miles in length, and is probably seven miles in width. We made a portage of a few steps from its south-west end to leave it, but we afterwards learned that this was not necessary and that the Indians usually follow the south-eastern shore and pass up the Camsell river into the next lake called Lac Rey, which is marked as lying to the south of Lac Ste. Croix. The country around Lac Rey is low and uninteresting with numerous grassy swamps near the water's edge. It is about seven miles in length and lies almost east-and-west. Its shores are well wooded. Here I noticed the Banksian pine for the first time in going south. We experienced some difficulty in finding our way out of Lac Rey, but at last discovered the Camsell river entering it with a small chute at its eastern extremity. Just above this chute, we came into a narrow lake about nine miles long, lying almost north-east and south-west. High rounded hills lie to the east of it and they seem to belong to the low range which was seen before towards the south-west. Here again we had difficulty in finding our way out. Naturally we passed right to the south-eastern end and here found the river flowing in. But just above the entrance it divided into two, one branch flowing from the south-west and the other and larger branch from the south. We followed the latter up through a small expansion and soon came to a rapid where we were disappointed to find that no Indians had passed

Lac Ste. Croix.

Lac Rey.

Route difficult to find.

that way lately and there were no signs of a portage-trail at the rapid. We had come the wrong way and were again obliged to turn back.

In order to save time, I went to the top of a high hill which lay near the lake and from it I saw a string of lakes stretching off towards the south-east from the southern end of Lac Fabre. This was near a place where we had seen some old Indian camps. Going to it, we found a portage-trail leading to a small lake about 300 yards from Lac Fabre. On paddling to the end of this small lake, we easily found a portage leading into another lake about two miles in length, whence a rough hilly portage led us into a rather large lake, which I have called Lake Rogers. This is a very pretty sheet of water filled with numerous tree-covered islands and bounded to the south-west by low wooded hills. Lake Rogers is almost twelve miles in length. The Camsell river enters it by two mouths at its north-east end and leaves it with a rapid about half way down its western shore.

Lake Rogers.

Track survey made.

Here again we missed our way and lost nearly a whole day by going to the foot of Lake Rogers, whereas we should have left it very near the place where we entered it. But owing to having made this mistake I was able to get a complete track-survey of the lake and I also saw something of the country to the south-west of it, as I made an excursion into the interior from that end, hoping to find the portage out of the lake. The sheltered channels of Lake Rogers were filled with yellow pond lilies and potomogetons. Passing up the Camsell river from Lake Rogers, we were obliged to make a short portage around the Duck falls, some two or three miles to the north-east of Lake Rogers, and above these we entered Lake Grant. To the north of Lake Grant are high rounded hills, a continuation of those seen on Lac Fabre. Lake Grant has its greatest length (a little over six miles) from east to west. The Camsell river flows into it at its extreme eastern end, but between it and Lake Rosamond, which is the next lake, the river is too rapid to be followed and a portage is made into a bay of Lake Rosamond, which approaches to within a quarter of a mile of Lake Grant.

Lake Grant.

Good portage-trail found.

Here we were surprised to find a broad and well used portage-trail, after the poorly cut portages we had heretofore passed over, but we afterwards learned that we had so far been following a mere hunting trail, the regular route to Lake Rosamond from the north coming farther to the east of Lac Ste. Croix, and from the north-east end of Lac Fabre it strikes directly to Lake Grant. Lake Rosamond lies also north and south. It is over twelve miles long and like most of the northern lakes, it is much divided into bays and is filled with

islands and has an exceedingly intricate shore-line. To the east of the lake runs a range of high mammillated hills, whose direction is almost north and south. To the west a single mound-like hill rises to a height of 1,000 feet. A country thickly wooded with aspen, balsam-poplar, canoe-birch, white spruce and Banksian pine stretches to the south-west of Lake Rosamond. The Camsell river enters the lake at its extreme southern end, but being very rapid, it is not followed to the next lake south of it.

Hills east of lake Rosamond.

At Lake Rosamond we were fortunate enough to fall in with a party of Dogrib Indians, three of whom I engaged to guide us to Fort Rae. It was a great relief for me to meet these Indians. We had hitherto lost a great deal of valuable time in searching for portages and in endeavouring to find our way southward. Moreover, as the season was already far advanced, we never knew when we might have to stop and wait until the ice formed upon the lakes. We had also long been without regular provisions and were leading a hand-to mouth existence, depending entirely upon the proceeds of our nets and rifles.

Dogrib Indian engaged as guide.

Leaving Lake Rosamond, we avoided the Camsell river and followed, instead, a route of three short portages with two small lakes between, which brought us into Tenika-Dawaso-necka lake or Small Rats' House lake. This lake, with the exception of Lake Hottah, was much the largest lake which we saw on our journey through the country. It is a magnificent sheet of beautiful clear water, nearly twenty miles in length and almost half as wide. The hills which follow the eastern shore of Lake Rosamond are continued along the eastern shore of Dawaso-necka lake at some distance to the south-east of it. The most prominent peak of these hills, which lies towards the northern end, gives the lake its name from its conical shape. This peak rises to a height of over 1,000 feet and is a striking feature in the landscape. The eastern shore of Dawaso-necka lake is thickly studded with islands, many of which, being high and rocky, give to the lake scenery a particularly pleasing effect. Leaving Dawaso-necka lake at its south-eastern end we entered a small rapid a few yards in width and on account of the small size of the stream we had some difficulty in making the few miles which intervened between Dawaso-necka lake and Lake Sarahk. Our P. terboro canoe was too large for the stream and we often required to lift it out of the water in order to pass the shallowest parts. Lake Sarahk is about eight miles in length from north to south. Rounded rocky knobs follow its eastern shore, but tree-covered hills rise to the south-west. Lake Sarahk is said to be the source of the Camsell river.

Tenika-Dawaso-necka lake.

Lake Sarahk.

Height of land passed.

Passing out of it we made four portages, with small muskeg lakes between them, in order to cross the height of land into Nagle lake, from which the water flows towards Great Slave lake. Nagle lake is not the source of the western branch of the Marian river, as the waters of the last two small lakes on the height-of-land flow towards the south.

Marian river and lake.

We continued our journey without interruption down the Marian river to the lake of the same name, which is eighteen miles long by ten miles wide. In 1899, acting on Dr. Bell's instructions, I had made a track-survey of this fine body of water and in passing through it on the present occasion I added numerous details to this work and made some other improvements. The lake discharges into the head of the Fort Rae arm of Great Slave lake by the Willow river, a sluggish stream only two miles in length.

Cross Great Slave lake.

We reached Fort Rae on September 20th, and after paddling down the Arm to the main body of Great Slave lake, we crossed the latter in our canoe, going from island to island, although it was a hazardous undertaking at that time of the year, and arrived at Fort Resolution on the 29th. Without loss of time we continued our journey by canoe up Slave river to Fort Chippewyan on Athabasca lake. As canoe navigation was now closing, we remained at this post until ice had formed of sufficient strength for safe travelling up the Athabasca river, which was not until November 14th. On that date we started for Edmonton and arrived there on December 7th, and reached Ottawa on the 12th.

Edmonton reached.

Acknowledgments due.

While engaged in the above work, a helpful spirit was manifested by everyone I met in my journeys, so that it would be difficult to enumerate here all the kindness I received, but special acknowledgment is due to Mr. F. C. Gaudet, in whose house at Fort Resolution I spent the winter, to Chief Factor J. S. Camsell, in charge of Fort Simpson when I passed down the McKenzie river, to Messrs. Hislop and Nagle and to the various Catholic and Protestant missionaries throughout the country.

The following general account of the geology of the region surveyed or explored appeared in my Summary Report on the above work:

GEOLOGY.

Geology.

The south-western portion of Great Bear lake, known as Keith bay, together with Smith bay and Dease bay to within thirty miles of

Fort Confidence, are surrounded by unaltered and almost horizontal Cretaceous strata. There are few outcrops of solid rocks, but shales and sandstones are exposed along Smith bay, and the Sweet Grass hills represent a low anticlinal fold, composed of hard sandstone, which acts as the backbone of the Gros Cap peninsula. Clay-shales, boulder-clays, gravels and unconsolidated sandstone are exposed at various places within the Cretaceous area and these all show a bedding which is almost horizontal. Presumably Cretaceous rocks are also exposed along the shore of MacTavish bay, east of Cape MacDonnel. On the Bear river, the Bear River Tertiary, similar to that already described by Mr. McConnell, at Fort Norman, extends some seven or eight miles up the river, and consists chiefly of unaltered and slightly consolidated sandstones in horizontal beds. Arenaceous shale and thin lignite seams are occasionally interstratified. The beds are often overlain by boulder-clay and cut sand-banks are common. Beyond the Tertiary basin, Cretaceous rocks extend to "The Rapid," where a rocky range of Palæozoic strata, crosses the river. Above this, there are frequent exposures of Cretaceous rocks, with some fossils almost as far as Great Bear lake. Here they consist chiefly of dark ferruginous and arenaceous shales overlain by thin-bedded and jointed light-yellow sandstones. Talus slopes are common. The beds dip down-stream at a very slight angle. It is from a stratigraphical and lithological comparison with the rocks of Bear river, that the rocks of Great Bear lake are referred to the Cretaceous, as nowhere on the lake were fossils found. On the upper part of Bear river are horizontal gravel beds of sixty and seventy feet in thickness, overlain by Pleistocene deposits. These gravel beds are probably analogous to those beds of the Mackenzie river which Mr. McConnell there calls Saskatchewan gravels. They are exposed at several places in the Cretaceous area.

Cretaceous rocks.

Bear River Tertiary.

Beds analogous to Saskatchewan gravels.

'Ordovician or possibly Silurian rocks occur at "The Rapid" on the Bear river where the mountain range crosses it. Mount Charles, the most prominent part of these mountains, is a hill of about 1,500 feet in height, and consists of a large anticline, embracing subordinate folds. The rocks are interstratified conglomerates, quartzites and magnesian limestones; the latter of great thickness. I found thin layers of gypsum in several places, interstratified with dark-gray, shaly dolomite. Salt springs are mentioned by Sir John Franklin as occurring here, but I was unable to locate them, and my Indian guide had never heard of their existence, although some thirty miles to the north-westward he knew of salt in quantity. From the description given by Richardson, it is probable that the promontory between MacVicar

Rock possibly Silurian.

Existence of salt springs not confirmed.

and Keith bays is Devonian, though I think from what the Indians say, Cretaceous rocks must occur there also.

Palæozoic boundary seen.

'Our route to Great Slave lake from Great Bear lake, lay not far east of the Palæozoic boundary, as could be seen by the outline of the hills to the westward, and at the head-waters of the Marian river; and at Nagle lake, the limestone rocks came to the water's edge. From this vicinity, however, the strike seems to be almost south, while our course was south-east, so that we did not see Palæozoic rocks again, till we arrived at Lake Marian.

Lower Cambrian rocks.

'From a point about thirty miles south-west of the mouth of the Dease river, eastward, exposures of solid rocks occur which are analogous to rocks seen last year on Great Slave lake, and there referred by Dr. Bell to the Animikie or Lower Cambrian. A low range of hills follows the shore of Dease bay for a considerable distance, and gradually approaches the lake-shore, till it terminates at a place called by Richardson, Limestone point, some twenty miles from Fort Confidence. The hills seem to be a series of anticlinal folds running almost parallel to Dease bay. Limestone point at its greatest height does not exceed one hundred feet. The lowest exposures are of purplish dolomite, which changes to a ferruginous slate. Above this comes gray, semi-crystalline dolomite, associated with light-gray quartzite. Rocks of like nature occur all the way to the Coppermine river, though isolated and small hills of both granite and syenite occur, which may be of different age. Along the Dease river the rocks consist chiefly of bright-red quartzite and drab and red magnesian limestones. Nearer the Coppermine, quartz-conglomerates, red and green shales, and pinkish sandstones are the prevailing country rocks. Amygdaloid is, however, found, together with some earthy volcanic rocks. In a range of hills running north-east and south-west, probably a spur of the Copper mountains, occur thick intrusive sheets of greenstone, frequently presenting steep mural precipices on either side. These hills rise to a height of about 1,000 feet. Greenstone rocks are also met with, near the mouth of the Dease river. Rocks similar to these occur for a considerable distance around the northern and north-eastern portion of MacTavish bay, and here greenstone intrusions with mural precipices, cutting through horizontal Lower Cambrian strata, are of common occurrence.

Hills of intrusive greenstone.

'The eastern part of MacTavish bay is composed of a series of basic rocks, or greenstones, that seem to overlie the Laurentian granites, of which, however, exposures are seen at several places. The southern part of MacTavish bay and the islands there, are mostly of granite,

though greenstone dykes are common. Crystalline rocks, composed chiefly of phorphyries, syenites and granites, with numerous greenstone intrusive sheets, occur all the way from Great Bear lake to Lake Marian. Hornblende gneiss is exposed on the Marian river. Certain rocks, met with near the headwaters of the Camsell river and near Lake Marian, may be referred to the Huronian system, or possibly they may be analogous to those met with on Great Slave lake, and named by Dr. Bell, the Intermediate series. Area of crystalline rocks.

'With regard to the occurrence of copper ores in the Great Bear lake country, I may say that in the amygdaloid and associated rocks near the Coppermine, specimens of chalcopyrite and stains of copper carbonate were found, but the locality of native copper, etc., spoken of by the old explorers was not met with, as it probably lies farther south. In the greenstones, east of MacTavish bay, occur numerous interrupted stringers of calc-spar, containing chalcopyrite and the steep rocky shores which here present themselves to the lake are often stained with cobalt-bloom and copper-green. According to Indian report, native copper occurs also at the north-east end of MacTavish bay. Siderite was found in pockets, in quartz and calc-spar in Cambrian rocks on the southern shore of Dease bay. Several other minerals seem to be connected with it. Iron ore in the form of reniform hæmatite, was found, but in uncertain quantity at Rocher Rouge on Edatravers bay, in the north-eastern part of MacTavish bay. Hæmatite also occurs near the Coppermine river and at several localities on the east shore of MacTavish bay. Here the ore is associated with what seems to be a dark-reddish trap, which I was unable to identify more precisely in the field. Talus slopes of the ore and country rock are common. Minerals. Occurrence of native copper not confirmed. Siderite. Iron ore.

'Evidences of glaciation, in the form of numerous glacial erratics were everywhere visible from the mouth of the Bear river, but it was not till the harder rocks of the Lower Cambrian were met with that glacial striæ were seen. The general course of the striation is a little north of astronomical west, though great local differences occur. On the barren lands near Dease river, I noticed glacial striæ in a direction N. 85° W. and fainter markings almost exactly at right angles. As Great Slave lake was approached, the course of striation seemed to be much more southward. Rows of drumlins, some of them three or four hundred feet in height, and long winding eskers were seen near the head-waters of the Dease river, and near Dismal lake, kames occur. Glaciation.

Recent ice deposits.

'Modern ice deposits are seen on the Bear river and are being annually added to by the ice freezing to the bottom around the shallow shores of Bear lake, and in the spring the ice rises and carries away pebbles, sand, and sometimes even boulders of good size.

Shore-lines on Great Bear lake.

Around Great Bear lake wonderful examples of old shore lines occur, showing the former extent of the lake. On the north-west side they exceed, in places, three hundred feet in height, and are at a distance of three to four miles back from the lake shore. This height on the north is much greater than any observed on the southern side, which might show a tilting of the lake towards the south or south-west. Besides these, broad beaches of one hundred to one hundred and fifty yards were often met with, and in places terraces of pebbles, showing old shore lines, extend for a short distance from the present shore of the lake, at various heights of from ten to one hundred feet. These are especially common in the northern part of MacTavish bay.'

APPENDIX

Descriptions by Dr. A. E. Barlow, of rocks collected in 1900, by J. Macintosh Bell, M. A., in Great Bear Lake District and thence to Great Slave Lake.

1. Mount Charles, Great Bear river.

   A fossil coral—*Halycites catenularia* (Fischer) var. *gracilis* (Hall).

   This fossil is distinctive of the Galena-Trenton formation in the west. It occurs abundantly around Lake Winnipeg. Further north Mr. J. B. Tyrrell obtained a specimen (loose) at Churchhill harbour. The same variety is characteristic of the Hudson River formation in Ontario (see page 69, Report on Corals by Mr. Lawrence Lambe). The above locality on Great Bear river therefore indicates a north-western extension of the Galena formation.

2. Great Bear lake, five miles S.W. of Limestone point. Quartzite grit.

   A deep flesh-red rock with more or less rounded individuals of grayish translucent quartz.

   Under the microscope the rock is seen to be made up largely at least of quartz, now for the most part forming an interlocking mosaic. The individuals of quartz differ greatly in size, but the larger ones are imbedded in a matrix relatively less in quantity, consisting of much smaller grains of quartz, together with a comparatively large amount of iron oxide. Felspar is either rare or entirely absent. The original clastic character of the rock is beyond a doubt as the outlines of the old and worn grains are still plainly discernible owing to the presence of films of iron oxide on the surface of these nucleal fragments. The eminently vitreous character of the rock is occasioned by the very complete infiltration of the secondary interstitial silica or cement in optical continuity with the original quartz fragments. It would be difficult to secure a more typical or characteristic example of this secondary enlargement of the quartz, so frequent in rocks of fragmental origin.

3. Great Bear lake, mouth of Dease river. Diabase.

A dark-greenish eruptive rock in which the ophitic structure may be seen by the unaided eye.

Much of the plagioclase is fairly fresh and the twinning lamellation is as a rule quite apparent. The tabular or lath-shaped individuals with well marked interlacing structure pierce allotriomorphic areas made up largely of calcite and serpentine, representing the original bisilicate material. Some of the plagioclase is altered chiefly to scapolite. Some scales of biotite may occasionally be noticed. Irregular grains and skeleton octahedral crystals of titaniferous magnetite are rather abundant.

4. Great Bear lake district, south shore Dease bay.

A brownish-gray fragmental rock.

The rock is very much decomposed and portions of it are abundantly stained with iron hydroxide. The thin section shows an association chiefly of calcite and quartz with irregular individuals of pyrite. It is probably some decomposed rock of tufaceous origin.

5. South shore of Dease bay, Great Bear lake district.

The hand specimen shows a yellowish-brown and greenish fragmental rock.

Under the microscope more or less rounded fragments of volcanic rocks together with much smaller individuals of quartz are embedded in a matrix made up chiefly of calcite. The volcanic fragments include various glassy and sometimes cellular leaves with small indefinite lath-shaped crystals of felspar. It is a pyroclastic rock, probably a porphyrite tuff.

6. Black rock, Great Bear lake.

A massive, medium-grained, dark greenish-gray eruptive rock. The thin section shows a diabase with somewhat coarse ophitic structure.

The tabular crystals of plagioclase, most of which have undergone advanced saussuritzation pierce the irregular individuals of pale-coloured augite. Many of the augite crystals are twins and some show incipient alteration to brownish-green compact hornblende. Areas of greenish serpentine are rather abundant. Grains and imperfect crystals of iron ore, probably titaniferous magnetite also occur.

7. Mouth of Camsell river.

Porphyry.

The hand specimen shows a pale-reddish very fine-grained rock with small spots of some greenish mineral.

The thin section shows a fine-grained microgranitic ground-mass in which are embedded phenocrysts of decomposed felspar. Areas of a greenish decomposition product occur. Sericite is abundant and some larger individuals of quartz.

8. Great Bear lake district, 5 miles south of Dismal lake.

A reddish granitoid rock.

Biotite-granite or granitite.

The rock is made up of a crystalline granular admixture chiefly of orthoclase quartz and plagioclase. The biotite has been wholly converted into a deep green chlorite. The plagioclase is much more altered than the orthoclase, but both by their turbidity are in marked contrast to the quartz. The quartz shows undulous extinction as a result of strain. A little iron ore probably magnetite is present. Some calcite present in association with some of the chlorite suggests the presence of original hornblende.

9. Cache island, mouth of Dease river.

A dark greenish-gray comparatively coarse-grained eruptive rock.

Diorite.

The thin section shows the rock to be made up chiefly of plagioclase and hornblende. The plagioclase has undergone somewhat advanced saussuritzation, but the twinning lamellation is still plainly discernible in places. The hornblende is prevailingly green with often a brownish tint, and some portions and individuals are of a decided brownish colour. Apatite is rather abundant in comparatively large prismatic forms. Iron ore probably titaniferous magnetite is abundant in irregular grains, and imperfect skeleton, octahedral crystals.

10. South-east shore, Lake Rosamond.

A flesh-red comparatively coarse-grained porphyritic granite. The thin section shows a crystalline admixture of microcline, microperthite, plagioclase, quartz and biotite which has been almost wholly converted into chlorite. The felspar shows partial alteration, especially the plagioclase, but some of the microcline is quite fresh. Occasional rather large imperfect prisms of

zircon were noticed. Ilmenite altered to leucoxene and iron hydroxide are often associated with the chlorite. Small prisms of apatite likewise occur.

11. Windy bay, Great Bear lake.

A very fine-grained, mottled greenish and red cherty rock. The thin section shows a decomposed ground-mass in some places very fine-grained and stained reddish by iron hydroxide, while in others it has become more or less devitrified with accompanying decomposition, and is now made up of indefinite lath-shaped crystals largely replaced by chlorite. In this ground-mass are embedded phenocrysts of felspar which have undergone rather advanced alteration. Magnetite is present in irregular grains. This rock is closely related to No. 12 and is probably a portion very poor in phenocrysts.

12. Echo bay, Great Bear lake.

A dark reddish-brown porphyritic rock

The thin sections show a microfelsitic ground-mass, which is in part replaced by chlorite and other decomposition products in which is embedded irregular phenocrysts of orthoclase, plagioclase, microperthite and quartz. The rock is a quartz porphyry which has undergone considerable alteration.

13. North shore of McTavish bay, Great Bear lake.

A greyish comparatively coarse-grained granitic rock. The thin section shows a biotite-granite or granitite. It is composed of orthoclase, plagioclase, microcline, microperthite and quartz with a smaller proportion of biotite which has been wholly converted into chlorite. The plagioclase has undergone advanced alteration and forms the pale-yellowish grains seen in the hand specimen. It is replaced now largely by scales and plates of sericite together with a much smaller proportion of calcite. The other felspars are quite fresh.

14. Echo bay, Great Bear lake.

A dark-grey porphyritic rock.

The thin section shows a porphyrite. The ground-mass varies in texture from microgranitic to microfelsitic, with a rather large proportion of green chloritic decomposition product. In this are embedded phenocrysts of plagioclase, some of which are largely altered to calcite. Irregular spaces are now occupied by what is apparently secondary quartz and calcite. Magnetite is rather abundant in irregular grains and occasional octahedral crystals.

15. Five miles north of mouth of Camsell river.

A dark-brownish porphyritic rock.

Porphyrite.

The thin section shows a reddish-brown for the most part isotropic ground-mass in which are embedded phenocrysts of plagioclase. The ground-mass has a striking perlitic structure, decomposition taking place along the cracks. Considerable areas of greenish decomposition product occur. Magnetite is present in irregular grains.

16. Three miles south of mouth of Camsell river.

Porphyrite.

A dark-brownish groy porphyritic rock.

The thin section shows a microgranitic ground-mass with a considerable amount of chlorite, in which are developed tabular phenocrysts of plagioclase. Considerable areas of chlorite occur, which doubtless represent the original bisilicate mineral.

17. Echo bay, Great Bear lake.

A dark-gray porphyritic rock.

The thin section shows a porphyrite. The ground mass is microfelsitic, often decomposed with the formation of secondary sericite and calcite, and with very abundantly disseminated grains and dust-like particles of magnetite. It is also stained in places by iron hydroxide. In this are embedded phenocrysts of felspar, probably plagioclase. This is so much decomposed that the twinning striæ are obliterated, but the character and disposition of the secondary scales and plates of calcite and sericite show that most of the porphyritic individuals are plagioclase.

18. Echo bay, Great Bear lake.

A fine-grained reddish jaspery rock.

The thin section shows a fine-grained rock consisting essentially of quartz together with a comparatively large proportion of hæmatite. It appears to be an acid lava which has undergone advanced devitrification. There is a marked spherulitic structure with separating areas of holocrystalline material, the whole intimately penetrated by minute beautifully dendritic forms of hæmatite. A little calcite was noticed in irregular grains.

19. North end of Hottah lake.

A dark-greenish gray, massive, eruptive rock with a reddish tint owing to the abundance of disseminated deep-reddish crystals of felspar.

The thin section shows a diorite made up chiefly of greenish, strongly pleochroic hornblende in irregular individuals and felspar, most of which at least is presumably plagioclase much decomposed and stained by iron hydroxide. A little orthoclase is present, and quartz for the most part in association with felspar forming areas of granophyre which fill up irregular interspaces between the other constituents. Magnetite is abundant and pyrite is also present.

20. Middle of Hottah lake, Great Bear lake.

A dark-greenish, somewhat coarse, basic eruptive rock, in which a rude ophitic structure is plainly discernible.

The thin section shows an association of tabular crystals of decomposed plagioclase, penetrating allotromorphic masses of green strongly trichroic green hornblende. A large amount of ilmenite almost completely altered to leucoxene occurs, as well as long acicular prisms of apatite. The rock is a uralitic diabase.

21. Five miles south of Big point, Great Bear lake.

A dark-gray porphyritic rock.

The rock is evidently a hypabassal form of the porphyrite approaching the so-called propylite of Hungary and Western America. Some portions of the rock present a distinct and decided although comparatively coarse ground-mass with phenocrysts chiefly of plagioclase and areas of chlorite. In other places no sharp line exists between the phenocrysts and ground-mass and the rock shows a disposition to assume the holocrystalline structure. The magnetite is abundant in irregular grains, while occasional plates of biotite occur. The rock is much decomposed and traversed by veins of chlorite and calcite. (Occasional irregular plates of altered biotite).

22. Middle of Lake Manai.

A pale reddish-grey compact arkose.

The thin section shows irregularly often angular, subangular, or rounded grains of orthoclase, plagioclase, microcline and quartz, together with small scales and plates of biotite, most of which has undergone more or less complete chloritization. These are

closely compacted together with little or no finer interstitial material. A little magnetite is also present.

(Plagioclase, microcline, magnetite).

23. Four miles south of Poplar point, Manai river.

A fine-grained compact brownish rock.

The thin section shows a fine-grained arkose made up of angular or slightly rounded grains of orthoclase, plagioclase and quartz closely compacted together. The felspars, which are very abundant, are much altered and stained with iron hydroxide. The rock has undergone considerable decomposition and chlorite is abundantly disseminated.

24. Fourth of six falls, Manai river.

A coarse reddish basic granitoid rock.

The thin section shows a hornblende-biotite-granite or hornblende-granitite made up chiefly of orthoclase, plagioclase, microcline and quartz, together with hornblende and biotite. Most of the felspars, especially the microcline are fresh, but some of the plagioclase shows incipient decomposition. A little epidote, occasional small prisms of zircon and irregular grains of magnetite are also present.

25. Ten miles south of Poplar point, Manai river.

A dark-gray porphyritic rock.

The thin section shows a fine-grained ground-mass in which are developed phenocrysts of felspar and quartz. Much of the felspar is plagioclase, but it is so decomposed that the twinning striae are very difficult to make out. Some yellow-brown areas now largely made up of epidote represent the original coloured constituent. Magnetite is rather abundant.

The rock is probably a quartz porphyrite.

26. Lake Rogers.

A flesh-red granitic rock traversed by small veins of chlorite.

The thin section shows a crystalline granular admixture of orthoclase, microcline, plagioclase and quartz, with irregular scales and plates of chlorite, most of which has probably been derived from the decomposition of biotite. Granophyre is very abundant and characteristic.

27. Hottah lake.

A massive greenish-gray eruptive rock.

The thin section shows a rock composed chiefly of plagioclase and hornblende. The plagioclase has undergone advanced decom position to saussurite forming an interlacing network of tabular crystals piercing the allotromorphic hornblende. Biotite and epidote also occur aggregated together in small masses.

Magnetite, probably titaniferous, likewise occurs.

28. North end of Lac Ste. Croix.

Granite-porphyry.

The hand specimen shows a porphyritic rock with a dark-grayish ground-mass in which are embedded large phenocrysts of reddish felspar and much smaller individuals of grayish translucent quartz.

The thin section shows a comparatively coarse microgranitic ground-mass made up of quartz, orthoclase, plagioclase and a large amount of chlorite, and some ilmenite decomposed to leucoxene. Granophyre is very abundant and characteristic. In this are embedded large phenocrysts of microperthite and orthoclase and smaller decomposed individuals of plagioclase. Quartz in rounded dihexahedral crystals is also abundant.

29. North end of Lake Marian.

A dark-gray gneissic rock, evidently one of the more basic gneisses usually classified as Laurentian.

The thin section shows a rock made up chiefly of orthoclase, plagioclase, quartz and biotite. Much of the felspar is more or less turbid as a result of decomposition. The biotite is reddish-brown in colour and its marked parallel disposition gives the rock its very evident foliation.

30. North end of Lake Rogers.

A comparatively coarse-grained hornblendic rock with conspicuous deep-red individuals of felspar.

The thin section shows a quartz-mica diorite. The plagioclase has undergone advanced decomposition so that only in rare instances can the twinning lamellæ be distinguished. A clear mineral, probably quartz fills in the irregular interspaces. The hornblende is the green compact variety. The biotite has undergone considerable bleaching and chloritization. A little epidote and apatite are also present.

D. B. Dowling.—Photo. 1895.

ANTICLINE IN CHAZY.—HOGS BACK, RIDEAU RIVER, GLOUCESTER TOWNSHIP, CARLETON COUNTY, ONT.

GEOLOGICAL SURVEY OF CANADA
ROBERT BELL, M.D., D.Sc., LL.D., F.R.S., DIRECTOR.

REPORT

ON THE

GEOLOGY

AND

NATURAL RESOURCES OF THE AREA

INCLUDED IN THE

MAP OF THE CITY OF OTTAWA AND VICINITY

BY

R. W. ELLS, LL.D., F.R.S.C.

OTTAWA
PRINTED BY S. E. DAWSON, PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1901

No. 741.

ROBERT BELL, M.D., D.Sc, LL.D., F.R.S.,
Director, Geological Survey of Canada.

SIR,—I beg to submit herewith a report on the Geology and Natural resources of the area included in the map of Ottawa city and vicinity. This map is on a scale of one mile to an inch, and is nearly in the form of a square, being twenty by twenty-two and a half inches, embracing a total area of 450 square miles, the city of Ottawa being taken as the central point. The geological structure is in places rendered quite complicated by the presence of several faults, some of which are of considerable extent, while over much of the district there are heavy deposits of clay and sand, which conceal the underlying rocks. In this case, information has been obtained by wells and by bore-holes, which have been sunk to the rock formation, and in some cases have penetrated these for several hundred feet. The accompanying lists of fossils, to illustrate the palæontology of the area, have been prepared by Dr. H. M. Ami.

I have the honour to be, sir,
Your obedient servant,

R. W. ELLS.

OTTAWA, September 26, 1901.

NOTE.—*The bearings given throughout this report refer to the true meridian.*

REPORT

ON THE

GEOLOGY AND NATURAL RESOURCES OF THE AREA

INCLUDED IN THE

MAP OF THE CITY OF OTTAWA AND VICINITY

BY

R. W. ELLS, LL.D., F.R.S.C.

The accompanying map of Ottawa city and vicinity is one of a series, contemplated for some years by the Geological Survey and intended to depict the geology and topography of the leading cities of eastern Canada. The topographical portion was commenced some years ago by the late chief-draughtsman, Mr. Scott Barlow. On his death, the work was taken up by his successor, Mr. James White, by whom the principal points in the compilation were determined, and the final compilation has been done by the present chief-draughtsman, Mr. C. O. Senécal. The necessary surveys have been made from time to time by different members of the staff, including the gentlemen mentioned, and completed by the writer of this report, in connection with his work in the areas along the Ottawa river, while large collections of fossils have been made throughout the area by Dr. H. M. Ami and others.

Compilation of the map.

The locality represented is a most interesting one from a geological standpoint. All the Palæozoic formations are present in the district from the base of the Potsdam sandstone to the Medina, and most of these are highly fossiliferous. The area more immediately about Ottawa has been affected by a great series of disturbances which have produced complications of structure through faults and foldings of the strata. Some of these dislocations are merely local displacements, but several are of greater vertical extent, affecting all the formations to the top of the Lorraine. That other overlying formations at one time existed in the area, may be inferred from the presence of

Formations represented.

isolated patches of red shales, now resting upon the Lorraine, and regarded as of Medina age. These outcrops of the Medina are, for the most part, situated a short distance to the south-east of the map-sheet, but one small area of the red shales is found in the bed of a brook near the south-east angle.

Drift.

Much difficulty has been found in the attempt to accurately map the several geological boundaries throughout the area owing to a very widespread mantle of drift. This consists largely of clay and sand, the thickness of which is in some places very great. This feature will be readily seen from the description of a number of bore-holes made quite recently in the country south of the Ottawa river.

Area included in map and report.

The area of the map-sheet is 450 square miles, the city of Ottawa being taken as the centre. It includes in the province of Quebec, portions of the townships of Hull and Templeton, and in Ontario, which lies to the south of the Ottawa river, a large part of the townships of Gloucester and Nepean, with small portions of Osgoode, Cumberland and March. The Ottawa river flows diagonally across the area from south-west to north-east, while the southern half is traversed by the lower part of the Rideau river, which joins the Ottawa in that part of the city known as New Edinburgh. The northern portion is also traversed by the Gatineau river which enters the Ottawa opposite the lower part of the city, and by the Blanche river, which joins it near the eastern limit of the map. Both these streams for the greater part of their course flow through the region occupied by the crystalline rocks, while the Ottawa and Rideau traverse the Palæozoic area.

Railway lines.

The country south of the Ottawa is generally level or slightly undulating. It is crossed by several lines of railway, including the Canadian Pacific (South shore), the Ottawa and Prescott branch and the main line of the Canadian Pacific west of the city, by the New York and Ottawa southward, and by the Canada Atlantic (O., A. & P. S. Ry.) westward. The area north of the Ottawa is also traversed by the Canadian Pacific (North shore), by the Ottawa, Northern and Western (G. V. Ry.), which follows the west bank of the Gatineau river for some miles north, and the Pontiac and Pacific Junction, a part of the latter system, which follows up the north side of the Ottawa.

Elevations above sea-level.

For convenience in determining future measurements, the following lists of elevations along the principal lines of railways which radiate from Ottawa city may be given. They have been furnished through the courtesy of Mr. James White, geographer to the Department of

the Interior. There are three railway stations in the city, viz., the Central, with an elevation of 212 feet above sea-level, located at Sappers bridge, the Sussex street station, 190 feet, and the Union station, near the Chaudière, with an elevation of 175 feet. Most of the railway lines now start from the Central station.

Along the Canadian Pacific (South shore), the elevations of the principal stations and crossings eastward, are as follows :— Canadian Pacific (south shore)

	Feet.
Central station	212
Crossing of Rideau river	198
" Greens creek	218
Blackburn station	230
Navan "	240
Brook crossing, one mile east	260
Leonard station	272
Summit, three miles east	279
Crossing of Rockland branch, Hammond station	220

The latter point is 22½ miles east of the Central Station, Ottawa.

On the Canada Atlantic railway, which starts from the same station, the elevations are : Canada Atlantic east.

	Feet.
Crossing of the Rideau river	194
" Ottawa and Prescott branch	197
" Greens creek	219
Eastman station	225
Summit, $4\frac{7}{10}$ miles east	254
Bearbrook station	249
South Indian, junction with Rockland branch	232

The latter point is 22½ miles east of the Central Station, Ottawa.

On the New York and Ottawa railway, also starting from the same station, the elevations are : New York and Ottawa.

	Feet.
Junction with C.P.R. south of Rideau river	200
Hawthorne station, crossing of C.A.R.	220
Russell road, at Ramsays Corners	240
Summit, 1½ miles south	266
Piperville crossing	261
Edwards station	258
Russell station	236
Embrun station, near the Castor river	223

The latter point is 23 miles from the Central Station, Ottawa.

Ottawa and Prescott branch.

On the Ottawa and Prescott branch of the Canadian Pacific railway, starting from the Sussex street station, at an elevation of 190 feet, we have :

	Feet.
Rideau river crossing	190
Montreal road crossing, Janeville	187
" and Ottawa Junction	193
Chaudière Junction with line to Union station	274

On the same line, starting from the Union station, at an elevation of 175 feet, we have :

	Feet.
Crossing of the Rideau canal	216
" Rideau river	213
Chaudière Junction with Sussex street branch	274
Gloucester station	345
Summit, $\frac{1}{5}$ of a mile south	353
Manotick station	327
Osgoode station	301
Sabourin station	284

This point is $24\frac{3}{5}$ miles from the Union station.

Canadian Pacific west.

On the Canadian Pacific main line west, also from the Union station, at 175 feet, we have :

	Feet.
Skead station	214
Britannia station	199
Bells Corners station	299
Stittsville station	396
Summit, $3\frac{7}{10}$ miles south	487
Ashton station	446
Carleton Junction	447

This point is $27\frac{3}{10}$ miles from the Union station.

Canada Atlantic, O. A. & P. S. Ry.

On the Canada Atlantic, O., A. and P. S. railway, starting from the Central station at 212 feet, we have :

	Feet.
Elgin street station	218
Chaudière Junction on Rochester street	206
Crossing of Ottawa and Prescott branch at 207 feet	229
Summit, $3\frac{3}{10}$ miles west	279
Crossing of Richmond road	225
South March station	285
Carp station	311

This point is $22\frac{4}{10}$ miles west of Ottawa.

All these roads traverse the area south of the Ottawa river

Of the roads which cross the Ottawa and traverse the northern portion of the map-sheet, the following may be given :—

Canadian Pacific Railway (North shore), starting from the Union station, at 175 feet. Canadian Pacific (north shore).

	Feet.
Ottawa river, bridge	188
Hull station	189
Gatineau river, bridge	181
Gatineau station	174
East Templeton station	159
Crossing of Blanche river	150
L'Ange Gardien west, station	183
Crossing of Lièvre river	183
Buckingham station	183

This point is 20½ miles east of Union station.

On the Ottawa, Northern and Western railway, we have the following :— Ottawa, Northern and Western (Gat. Val. Ry).

	Feet.
Ironsides station	182
Crossing of stream, half a mile east	194
Chelsea station	365
Summit, ½ mile north	395
Depression near the Gatineau, 1 $\frac{7}{10}$ miles north	288
Kirks Ferry station	294
Summit 2½ miles north	363
Cascades station	304
Patterson creek crossing	317
Rockhurst station	327
Wakefield station	326

This point is 21 $\frac{8}{10}$ miles from Union station.

On the Pontiac and Pacific Junction railway, same system, starting now from the Central station at 212 feet :— Pontiac and Pacific Junction railway.

	Feet.
Interprovincial bridge	190
Hull station	163
Deschênes station	198
Aylmer station	217
Crossing of brook 1½ miles west	224
Crossing of Breckenridge creek	214
Breckenridge station	215
Tremblay station	211
Eardley station	215
Parker crossing	232
Mohr station	226
Quyon station	275

This point is 23 miles west of Aylmer station.

These levels are given beyond the limits of the map-sheet, including a radius of practically twenty miles from the several stations in the city. They will serve as a basis for future work for local observations in working out the surface geology of the district.

Borings.

In this connection it may be mentioned that the depths of the overlying clays and sands has been ascertained over quite a large area by means of numerous borings. These have in many cases been sunk to the underlying rock in the search for water or in explorations for gas or oil, work for this object being now carried on at several points in the area south of the Ottawa.

Provisional boundaries.

This widespread area of drift has interfered very considerably with the exact delimitation of boundaries in the district both to the north and south of the Ottawa river. In certain cases therefore the extension of the formation lines is necessarily conjectural and must be held to be subject to revision as new data are obtained.

Boring near Ramsays Corners.

Among the many borings which have been put down through the drift in the area near the city may be mentioned that recently made by a company now boring for gas and oil in the township of Glouces ter, a short distance south of Ramsays Corners, on lot 18, range VII., Ottawa Front. Here a thickness of 186 feet of clay was passed through, underlain by eighteen feet of gravel which rested on the denuded surface of the Lorraine formation. At the new Rockcliffe rifle range also the clay deposit near the Ottawa river has a thickness of 169 feet, beneath which there were three feet of gravel before reaching the rock, which here is presumably the Chazy shale.

Rockcliffe rifle range.

Of former borings in the district several records have been handed to the writer through the courtesy of the Hon. Senator Poirier. The principal of these have been summarized and may be here given.

Borings near Montreal roa

Thus at a point about five miles north-east of Eastman Springs the drill passed through 125 feet of blue clay. Another boring near the village of St. Joseph d'Orléans had 124 feet of clay, and yielded a strong overflow of saline water, and a third boring on the road between Gloucester and Cumberland, about two miles south of Orleans village, reached the rock at fifty feet, with a flow of fresh water.

In the south-east corner of Gloucester township the clay has a thickness of 110 feet. On the road to Greens creek, about four miles from Cummings Bridge, the blue clay is 125 feet thick, and near the line between Cumberland and Gloucester, about one mile from the Mon-

treal road, the thickness is 150 feet with a strong overflow of fresh water which was also found in several other wells in the vicinity.

One mile north-west of Veighton, on the property of Alex. Murray, the clay has a depth of 114 feet, with very salt water, and at the bottom about five feet of gravel was found. South of this about one mile, in the north-west corner of Russell township, several holes were bored to depths of sixty to seventy-five feet, passing through red clay with an underlying gravel and yielding fresh water. Russell township.

At Cumberland village the depth of the clay was found to be eighty feet with two feet of gravel at the bottom, while several other wells in the vicinity show the gravel to be absent. At Sarsfield in an area from about one mile north to two miles south, the drift was only forty feet thick with twelve feet of gravel at the bottom. Three miles north of Sarsfield the drift ranged from twenty-five to thirty feet and had an underlying gravel, yielding fresh water. Near Bearbrook several wells ranged from seventy-five to one hundred feet in depth, with the gravel at the bottom. This is probably underlain by Lorraine or Utica. Cumberland. Bearbrook.

In order to show the wide areas of this drift a few notes of borings further east may be given. Thus in the township of Clarence, one mile south of Rockland, borings at several points gave a thickness of clay of seventy-five to one hundred feet, with eighteen to twenty inches of gravel at the bottom. At Hammond, ten miles south of Rockland, one hundred feet of blue clay with a heavy stratum of quicksand at the bottom. At Cheney, two miles south of this place and four miles north of South Indian, on the Rockland branch railway, three wells gave 103 feet, including twenty feet of quicksand at the bottom. In the vicinity of Cobbs lake, several holes showed 110 feet of clay but no gravel, the lower part passing through black clay which probably represents the top of the Utica shales. On what is known as the Brook, five wells gave depths of 130 to 135 feet, with nine to ten feet of gravel at the bottom. At Wendover near the Ottawa river, the clay was 160 feet deep. At Pendleton, south of this and near the South Nation river, 116 feet of blue clay with two feet of gravel, were found. At Plantagenet village the clay was 112 feet thick, with saline water, and a short distance east of the village of Curran, two wells gave 150 feet of clay with four feet of gravel, yielding saline water; while on the north bank of the Nation river, at the ferry to Fournierville, the clay had a depth of 180 feet, and the boring yielded quantities of saline water and gas. Two miles east of this another boring passed through 186 feet of clay and also produced saline water and gas. Near Rockland. Hammond. Cheney. Cobbs lake. Pendleton and Plantagenet. Deep boring on Nation river.

Old channel of the Ottawa.

The records of these wells furnish some important information, not only as showing the character of the waters at different points in the district, but as proving very clearly the great amount of denudation which has taken place in the area south of the Ottawa. They seem to indicate that an old channel of the river passed in this direction a few miles south of the city, extending across the area now occupied by the Mer Bleue and thence eastward along the stream known as the Brook, which takes its rise in the bog and joins the Nation river at the great bend south of Pendleton village, a few miles north of Casselman.

Clays north of the Ottawa.

North of the Ottawa the clay areas while extensive, are probably much less in depth. The range of the crystalline rocks approaches quite close to the river, and rock ledges are seen in close proximity in several places. The thickness of the clay deposits between Ironsides and Chelsea is, however, great.

Sand deposits near the Rideau.

Great deposits of sand also occur at a number of points in the area south of the Ottawa. They are well seen along the Rideau river and for some miles east and west of that stream. Thus in the township of Nepean in rear of the village of Merivale, these deposits are heavy,

Marine shells.

and large sand dunes are a prominent feature. These sand deposits cross the Rideau a short distance below and at Black Rapids about four miles south of Hogs Back, and at one point near the base, or at the contact with the clays, are large deposits of marine shells. This sand is used in Ottawa for building purposes. To the south of Bowesville, east of the Rideau, similar large deposits of sand occur over a considerable area, and they also appear along the road which skirts the north side of the Mer Bleue, as also in the southern part of the township of Gloucester, near the line of Osgoode.

Mer Bleue peat bog.

Large deposits of excellent peat are found at several places. The most important of these is that known as the Mer Bleue bog which lies between the Canada Atlantic and Canadian Pacific railways, to the north of the road leading to Eastman Springs. It extends across into the township of Cumberland and embraces an area of several thousand acres. The depth of the bog in places reaches nearly or quite thirty feet. Two streams rise in the bog, the Brook flowing east has already been referred to, while Greens creek flows from the western end and joins the Ottawa river about seven miles east of Ottawa city.

Gloucester and Osgoode bogs.

Another bog of large size is found on the town line between Gloucester and Osgoode, on range IV., about four miles east of the Rideau. This extends southward into Osgood for several miles, while a third but apparently shallow bog is crossed by the Ottawa and Prescott railway, several miles south of Chaudière Junction.

H. M. Ami.—Photo. 1900.

MARLS, GRAVEL AND SAND IN CLIFF, SOUTH SHORE HEMLOCK LAKE, OTTAWA, ONT.

H. M. Ami.—Photo. 1900.

SECTION IN SAND DUNE, RIDEAUVILLE, SOUTH OF RIDEAU CANAL.

Rock outcrops are rarely seen in the township of Gloucester south of a line from Leitrim post-office east to Blackburn, the southern part of the township being almost entirely drift-covered. The last exposure in this direction appears to be on the Russell road leading from Ottawa to Eastman Springs, about one mile south of Hawthorne corner near a church, where the Lorraine shales and sandstone are exposed in a brook, but several outcrops of the Calciferous are seen in the southern part of the township, about two miles east of the Rideau river. Rock outcrops.

The study of the geology of the district has also been made more difficult by the presence of numerous faults which traverse the area in different directions. Faulted area.

Some of these have affected the rocks of one formation only, but others have broken across all the formations from the Potsdam upward. As their presence is an important factor in the delimitation of geological boundaries, a brief description of the principal lines of dislocation may be given. Their extension is in many places entirely concealed under the mantle of drift, but several have been traced, at least as far as the conditions have permitted.

What is probably the greatest of these is known as the Hull and Gloucester fault. The eastern extension of this, lying beyond the limit of the map-sheet, need not be described, further than to remark that it proceeds westward from Rigaud mountain to the vicinity of Ottawa. This fault has been referred to in the Geology of Canada, 1863, page 116. Hull and Gloucester fault.

The prolongation of this fault from Rigaud enters the map-sheet near the south-east corner from the township of Osgoode. It thence follows a north-west course to within four miles of the Rideau river, to lot 10, range 3, Rideau front, when it inclines more to the north and crosses the river in the vicinity of the Canadian Pacific railway bridge. Here, on the south side of the Rideau, outcrops of Trenton limestone are seen near the bridge with a dip of N. 70° E. < 35°. Up stream, this dip gradually increases, till at a distance of seven and a half chains, it is N. 40° E. < 65°. The evidences of the dislocation are visible on both sides of the river. Extension across Gloucester to Hintonburgh.

From the Rideau crossing, the line of fault apparently follows a straight course to the Ottawa river in Mechanicsville, being well seen the Canada Atlantic (O., A. & P. S. Ry.), where the limestones dip on N. 47° E. < 57°, and in Hintonburgh, on the line of the Canadian Pacific railway, with a dip of N. 50° E. < 57°. Along the west side of the deep cove at the little Chaudière rapids, the Black River lime-

stone dips N. 65° E. < 47°. It here crosses the river to Tétreauville where the limestones dip N. 55° E. < 45°-60°, the strata along the river thence east to Hull being much disturbed and several other minor dislocations occurring in the area.

Fault from Tétreauville north.

Thence the fault inclines more to the east and continues to Fairy lake, keeping west of the Beaver meadow. At the north-east end of the lake the limestones dip N. 50° E. < 50°. Continuing north, it comes against the east flank of the crystalline rocks, about two and a half miles north of the Ottawa, and then apparently turns off at an angle north-east to the Gatineau river, which it is supposed to reach a short distance south of Wrights Bridge, about three miles above the mouth of that stream.

Inclined strata.

It will be noticed that along the line of this fault the strata are everywhere highly inclined. At the first contact with the Utica on lot 10, range 3, the dip of the Calciferous is N. 35° E. < 65°. Along that part of its course south of the Rideau, it brings the Calciferous against the Lorraine and Utica, and further north it involves the Chazy, Black River and Trenton, and brings them against the latter formation.

Fault in Nepean township.

In the description of this fault and anticlinal given in the Geology of Canada, it is stated that the extension of this line of disturbance is supposed to cross the southern portion of Gloucester and Nepean townships, and to extend westward through Huntley and Fitzroy. In the two townships first named, it apparently affects only rocks of Calciferous age, which occupy the country on both sides of the Rideau for some miles. But in the central part of Nepean, what may be an extension of this line of fracture, comes into view on lot 23, range IV., and here brings up the Black River and Trenton limestones against the Calciferous dolomite and Potsdam sandstone. Thence the fault extends westward towards Hazeldean, and continues along the southern flank of a prominent ridge of granite and other crystalline rocks for some miles.

Cross fault.

A transverse fault comes to that just described in Nepean township, near the line between ranges III. and IV., lot 22. This affects the Chazy, Black River and Calciferous formations. This fracture extends south-west into the township of Goulburn, where it apparently dies out in the Calciferous.

The faults just described are the most extensive in the area south of the Ottawa river. In the vicinity of the city, however, several others are known to exist which have had a marked effect in the distribution of the several formations there developed.

Some of these are mere local displacements of strata affecting merely one formation; but in the vicinity of Rockcliffe park, in the eastern part of the city, several important breaks are seen. They are visible on the shores of the Ottawa river below New Edinburgh, as well as at several points inland. They have not, however, the same amount of displacement as in the case of those recently described. Minor faults.

Among the most important of these near Rockcliffe is one seen on the shore near the end of the point below Governor's bay. Here several minor breaks in the strata occur, but the principal one cuts across the Trenton limestone with a dip of S. 10° W. $<42°$. It extends almost due east to the line of the Electric railway where it meets another line of fracture which follows along a depression which leads down to the shore in the bottom of a cove east of the point mentioned. Here the Trenton or possibly Black River limestone is brought against the Chazy shales by the cutting out of the great bulk of the Chazy limestone. From the point of intersection of the road it continues south-west for about twelve chains. Then it inclines sharply to the west passing to the south of the rear entrance to Rideau Hall to the corner of the roads at Ercildoun cottage, where it separates the Chazy limestone from those of Trenton age. At the latter point the Utica shales are supposed to be in contact with the former. Thence it takes a south-east course to the rear of Clarkstown where it is about twenty-five chains south-west of St. Patrick street bridge. Here it again turns to the north-east and reaches the entrance of Beechwood cemetery, where the Chazy limestone at a high angle is in contact with Utica shale. Another fault extends from this point north-east past the head of Hemlock lake in the direction of the Ottawa river which cuts out a portion of the Chazy limestone. Rockcliffe. New Edinburgh. Beechwood.

A second line of fracture comes to the south side of Governors bay from the rear of the Rideau Hall grounds which apparently affects the Trenton formation only. The course of this fault from the river is a few degrees south of west and it meets that just described on the back road east of the Rideau Hall grounds. Rideau Hall grounds.

To the north of Beechwood cemetery there is also probably a line of fault, separating the Trenton limestone in part from the Utica shale. This extends in the direction of the Montreal road but owing to the drift its exact position cannot be accurately laid down. Montreal road.

Further east in the direction of Greens creek another small dislocation is seen with an apparent throw to the north-east. This extends from the shore of the Ottawa to the Montreal road where it crosses Greens Creek fault.

to the south about one and a half miles west of the bridge over Greens creek. This traverses all the formations from the Chazy to the Utica both inclusive, the underlying Calciferous not being exposed owing to the clay covering which is heavy towards the river.

Hogs Back fault.

In the area south of the city along the Rideau river, near Hogs Back several other faults also occur. One of these is seen on the east bank of the river near the bridge across the dam at the entrance of the canal where it cuts out a large portion of the Chazy and Black River limestones. There is in the river at this place a well-defined sharp anticlinal in the lower part of the Chazy from which the place evidently takes its name. This fault can be traced down along the east bank of the river for half a mile, the strata at one point dipping S. 80° W. $<60°$.

Faulted area south.

South of the Hogs Back the continuation of this break can be observed in a small knoll about a fourth of a mile distant, where the Black River limestone is tilted at an angle of 65°, the dip being N. 10° E. The Trenton limestone alongside to the east dips east $<4°$–10°. Above this along the Rideau river two other faults are seen which occur in limestones of Black River or Chazy age, but these are apparently local in character or are so obscured by drift that they cannot be traced to any distance.

Old rifle range.

In the excavation for the main sewer across the old rifle range near the Rideau river, a small fault was noticed in the Utica shales, which has displaced the rocks to some extent. The fossils found on either side of the break are different in character, but the amount of the throw is probably less than fifty feet. On the west side of Parliament hill there is also a fault in the Trenton limestone, referred to in the Geology of Canada, 1863, page 166, which has caused a dislocation of the strata for seventy feet.

Dows lake.

A well-defined fault is seen on the east side of Dows lake, extending through the lumber-piling grounds from the end of LeBreton street south-east, and showing in a broken anticline northward near the crossing of the Canada Atlantic railway, at Rochester street, in the west part of the city. Along the contact near the pond, the Trenton limestone is much broken up for a breadth of six to eight feet, where it is in contact with the Utica shales.

Billings Bridge.

Several small faults are seen in the Utica formation south of Billings Bridge, in the exposures along the small brook at that place, but while probably other minor faults occur, it is thought that those already described include the most important lines of fracture in the vicinity of the city.

The deposits of sand and clay, which are widespread, have already been referred to. The latter is, undoubtedly of marine origin, since fossils are found in them at a number of places. In certain of the sands also, marine organisms have been obtained, as also in the inter-stratified gravels. Over large areas, however, these deposits are apparently barren of organic remains. Sands and clays.

Among localities where such organisms have been found, though the list is not regarded as complete, may be mentioned several points along the south shore of the Ottawa, near the mouth of Greens creek and at Besserers wharf, where the clay banks contain an abundance of clay nodules of different shapes and sizes. Some of these are round and apparently devoid of fossils, but others are elongated, flattened and kidney-shaped, and from these a great variety of organic remains has been obtained. These include the bones of seals, the remains of fishes of the genera *Cottus* and *Mallotus*, shells of several kinds, the feathers of birds, the remains of plants, leaves, etc., and other organisms around which the concretionary masses have been formed. These localities have long been noted for the occurrence of these remains. Marine fossils of Greens creek.

In some of the brickyards also these organisms are abundant, notably at that of Mr. Odell, in Ottawa east. Here, also, the bones of seals have been collected, with shells, sponges, etc., in abundance. In the clay excavations at different points throughout the city, shells are also obtained, and along the canal, at the Deep Cut. In the city of Hull, there is a stratum of clay, in a portion of a boulder ridge, which contains similar organisms showing its marine origin, in part at least. At the summit, half a mile north of Chelsea station, on the Ottawa, Northern and Western railway, shells are found in the base of the sand and gravel at an elevation of 395 feet above the sea. Along the Rideau river, about two miles above Hogs Back, a section of Leda clay, sand and gravel, 110 feet thick, on the west bank, contains a considerable variety of marine forms near the contact of the clay and sand. At Hintonburgh, a cutting on the Electric railway, near the junction with the Britannia branch, shows shells in gravel. They are also found in sand with clay partings, about the shores of Hemlock or Mackay lake, near Rockcliffe park, and in a gravelly soil near Chaudière Junction, on the Ottawa and Prescott branch of the Canadian Pacific railway. Odell's brickyard. Chelsea station. Rideau river. Hintonburgh.

Two interesting ridges of drift are seen in the northern portion of Hull. They are crossed by Chaudière street, from the intersection of Regent street north. The more southerly is composed chiefly of large blocks of Trenton and Black River limestone, in broad flat masses, and Boulder ridges in Hull.

has a breadth of about three chains; the second is made up largely of boulders of the crystalline rocks, derived from the mountain ridge to the north. It is in the former that the marine shells are found. These ridges can be traced across the portion of the city north of Lake Flora and are conspicuous features in this area.

Striæ.

Striæ are rarely observed in the district. The ice movement is nearly southerly. They have been noted near Old Chelsea with a direction of S. 10° E. and S. 20° E. In the bed of a brook which crosses the road west of the Rideau near Black Rapids lock, two sets were observed with a course of S. 20° E. and S. 55° E.; and on the crystalline rocks near South March station, on the Ottawa and Parry Sound railway, the course of the striæ is S. 10° E., and on the shore road half a mile west of Britannia, two sets, the direction being S. 55° E. and N. 73° E.

GEOLOGY.

Formations represented

The various formations recognized in the area included in the accompanying map may be thus stated :—

Medina red shales.
Lorraine shales and sandstone.
Utica shale.
Trenton limestone.
Black River limestone.
Chazy limestone.
Chazy shale.
Calciferous, mostly dolomite.
Potsdam sandstone.
Archæan.

Fossils

Large collections of fossils have been made from the rocks of all the formations in the district, except the Medina, by various officers of the Geological Survey and by other residents in the city interested in the subject, among whom may be mentioned Sir James Grant, Mr. Walter Billings, Mr. Walter Odell and Mr. T. W. E. Souter. The earlier collections were identified by the late Palæontologist of the Survey, Mr. E. Billings, and the more recent ones have been tabulated by Dr. H. M. Ami. His lists from the several formations are given in an appendix.

MEDINA SHALES.

Medina red shales of Osgoode.

The outcrops of the Medina indicated on the map-sheet are but small. The principal outliers are located a short distance to the south-east in the direction of Bearbrook. One small area is, however, found near the southern margin of the map, on the fourth lot of the eighth range of Osgoode, where the brook crosses the road to Metcalfe. This place is referred to in the Geology of Canada, 1863, page 219, under the head of Utica and Hudson formations. The red shales at this place, as also similar shales further east, overlie the Lorraine shales, and they are identical in character with the rocks classed as Medina in the area east of the St. Lawrence river, on the Bécancour, and described in the report on that locality in the Annual Report, Geol. Surv. Can. 1887-88, vol. III, page 118, part K. No fossils have been found in these shales as yet, and their horizon is therefore based on their position and lithological character.

At the locality mentioned the shales do not now show at the surface which is here drift-covered. The debris is, however, seen in the bank of the brook at the road crossing, and the rock itself was observed by Mr. James Richardson in his traverse of the district in 1853, in an excavation for a mill site, traces of which still remain.

Dickenson post-office.

Further to the south-east, however, near Dickenson post-office, the shale can be seen in several excavations and has a thickness probably of nearly 100 feet.

The locality in Osgoode township is in close proximity to the Calciferous dolomite, and is supposed to be in contact with that formation along the line of the Hull and Gloucester fault.

LORRAINE FORMATION.

Lorraine formation, character.

The shales and sandstones of this formation have been separated from the underlying Utica into which they pass downward gradually. They form a distinct series both in physical character and also in the contained fossils. The shales lack the black colour of the Utica and also their bituminous aspect, being generally some shade of gray, while they are distinctly sandy and have associated beds of sandstone. Occasional bands of a grayish dolomitic limestone are interstratified with the grayish dark shales.

Outcrops of shale.

Outcrops of the Lorraine proper are found on the road to Eastman, in a brook near the church between Hawthorne and Ramsays Corners, and the strata at this place contain an abundance of the fossils characteristic of the formation. On the road west of Ramsays Corners between lots 5 and 6, range V., Rideau Front, the gray shales are also exposed, and also on the road west of Hawthorne, where they pass down conformably into the Utica shale.

Canada Atlantic railway.

On the line of the Canada Atlantic railway, about one mile south of the crossing of the Rideau river, the grayish shales are again seen in a small cutting, and on the road towards Billings Bridge from the Hawthorne toll-gate the lowest members of the formation are exposed near the crest of the ridge, also indicating the passage beds to the Utica.

Areas in Russell township.

The rocks of this formation are supposed to occupy a large part of the township of Gloucester, crossing into Cumberland and Russell townships. Owing to the fact that most of this area is covered by drift and by the Mer Bleue bog, the outcrops are not seen at points other than those mentioned, but further east, in the vicinity of Bearbrook and on the roads west near Dickenson post-office, they are well exposed, coming out from beneath the drift. They are well seen on lots 23 to 25, ranges VII. and VIII. of Cumberland, and their contact with the Utica is observed about half a mile east of Bearbrook station, as also on several of the roads a short distance west of that place. They here contain fossils and the structure of the area appears to be basin shaped, of which the northern edge is defined by a curving line along the north side of the Mer Bleue. Southward the basin extends to the line of the Hull and Gloucester fault, and in support of this view a small outcrop of the shales was noticed near the east line of Osgoode, about lot 20, in close proximity to the Calciferous.

Extent and thickness of Lorraine.

The breadth of the area in the township of Gloucester should therefore be about eight miles. A recent boring at Ramsays Corners confirms the supposition that the formation is basin-shaped, and that it has a considerable thickness. This boring, on lot 18, range VII., Ottawa Front, passed through 204 feet of drift to the grayish shales. In this the drill penetrated to a further depth of 250 feet and apparently reached the top of the Utica at about 450 feet from the surface. As the Lorraine probably forms the rock at the surface, since it is seen about one mile to the north-west, this boring would give a thickness of 440 to 450 feet for this formation at this point.

This is the only opportunity yet afforded for ascertaining the thickness of these rocks in the whole of the area. At an assumed dip of

two degrees from the contact with the Utica near Greens creek, and supposing the inclination of the strata to be regular, this would be about the thickness of the formation at the bore-hole by calculation, so that there is no occasion for introducing a fault to account for this thickness in the Lorraine.

UTICA SHALE.

Utica shale.

The Utica shales differ from those of the preceding formation in the presence of carbonaceous matter, rendering them for the most part bituminous, and in their black or dark-brown colour. They underlie the Lorraine on the north and north-east throughout, and on the west near the city of Ottawa, as also on the south-west till they meet the Hull and Gloucester fault near the Osgoode line. The thickness of the Utica has never been satisfactorily determined, owing in part to the paucity of exposures over large areas, and also to the presence of numerous small faults which affect the shales. These are generally local in extent, but sometimes they continue into the adjacent formations.

Probable thickness.

As a rule the rocks lie nearly flat. Allowing a similar dip of two degrees as in the case of the Lorraine, the thickness of the formation in the north part of the basin would not be far from 400 feet, but this in the present state of our knowledge must be regarded as an approximation only, since it may be affected by faults not visible at the surface. No section exists anywhere in the area where the actual thickness can be measured.

Extent of the formation.

While the surface breadth of the Utica in the area comprised by the map is rarely much more than two miles and a half, this is much greater in the township of Cumberland to the east. Here the shales spread over a wide area and, between the villages of Russell and Sarsfield, are exposed at intervals for about eleven miles across the strike, forming a broad and generally level district, broken only by low hills.

Small areas near Dows lake.

The western outline of the formation is found in the city of Ottawa. Here the contact with the Trenton can be well observed on Preston street to the north of Dows lake. On the road to the Experimental Farm the breadth of the most westerly exposure is seven chains, and it extends north-westerly across Preston street to a short distance beyond Willow street, a distance of twenty-six chains. The rocks lie in a basin-shaped syncline, apparently conformable upon the upper part of the Trenton on both sides, the latter here forming a low anticline.

Faulted contact with Trenton.

A second small area of the shales is seen near the north-east angle of the lake. The contact of the Trenton occurs in the piling ground at the end of LeBreton street where there is a well marked fault. This area has a breadth of five chains on the lake and extends north-west for twenty chains, crossing Norman street and almost reaching Rochester street. The contact with the Trenton on the west is apparently a conformable one, while the line of fault on the east side continues north-west and is seen in a broken anticline just north of the Canada Atlantic railway. Southward the fault can be traced through the lumber piling grounds east of the lake, the shales being in contact with the broken edge of the underlying limestones for some distance.

Yet another small area of these shales occurs in this vicinity and is seen to the east of Preston street between Eliza and Poplar streets, beginning about three chains north of the Canada Atlantic railway and extending twenty-two chains north-west. The breadth of this outlier, which rests on the Trenton, is not more than three chains at the widest observed point.

Western outline of Utica shale.

The western edge of the Utica from the Preston street basin continues across Dows lake and swamp and crosses the Rideau river a few chains east of the railway bridge. Thence southward it is affected by the line of the Hull and Gloucester fault, and is in contact successively with the Trenton, Black River and Chazy limestones, Chazy shales and Calciferous dolomites, to a point about ten miles south of the Rideau River crossing, where it is probably overlain by the Lorraine shales near the line between Gloucester and Osgoode townships, on range VII. of the latter.

Exposures.

The shales of the formation are well exposed in the area north of Dows lake as also about Billings Bridge, Hurdmans Bridge and along the Metcalfe road in several places as far south as lot 17, range V, Rideau Front, and on a road east from this point between lots 15 and 16, for about one mile.

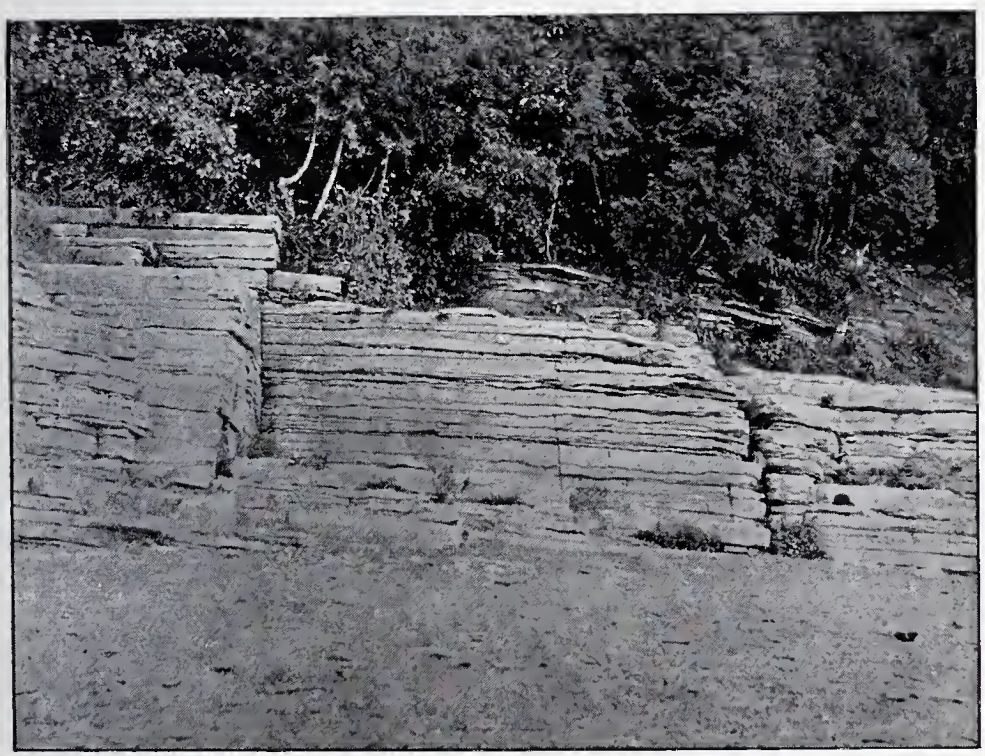
The formation underlies a large portion of Ottawa city but here the outlines are somewhat difficult to trace. Much information has been obtained from time to time, chiefly by Dr. Ami, from sewer excavations, as the rock outcrops rarely appear at the surface.

Area in New Edinburgh and at Beechwood.

In New Edinburgh the contact with the Trenton limestone is conformable and occurs near the line of Charles street, two streets east of Sussex street. Here the outline of the shales appears to make a sharp curve forming a shallow basin the northern margin of which extends westward along the face of the escarpment north of McKay

H. M. Ami.—Photo. 1900.

UTICA SHALE.—EXCAVATION ACROSS OLD RIFLE RANGE, OTTAWA, ONT.



H. M. Ami.—Photo. 1900.

TRENTON LIMESTONE.—FOOT OF PARLIAMENT HILL, OTTAWA, ONT.

street to the entrance to Beechwood cemetery being in contact for a portion of the distance with Chazy limestone, by the fault which extends west from the Government House grounds. Thence westward they continue through the flat north of Beechwood to the Montreal road, through a part of Notre Dame cemetery, the conformable contact with the Trenton being seen about six chains north of the Montreal road on a road leading past the east side of the cemetery. The contact with the Trenton thence keeps to the north of the Montreal road for about three-fourths of a mile and crosses to the south on lot 24, eleven chains east of the road leading to the shore of the Ottawa between lots 24 and 25. The dip of the Utica at the contact with the Trenton near the Roman Catholic cemetery is S. 40° E. $< 3°$–$4°$, and at the contact on lot 24 the dip of the underlying limestone is also about S.E. $< 2°$–$3°$, but several low undulations here occur. Montreal road.

Thence it keeps to the south of Robillard's limestone quarries for a short distance and then curves again to the north after passing the crest of the hill on the road to Greens creek, where it apparently meets a line of fault one mile and a half west of the road crossing that stream.

From this point eastward the northern margin of the basin is largely concealed by drift to the road leading north from Navan village where the direct and apparently conformable contact with the Trenton is seen at a point three fifths of a mile north of Navan corner, the underlying rocks dipping S. 50° W. $< 5°$. Contact near Navan.

From New Edinburgh the western limit of the basin can not be well traced, but it has been followed as fully as possible from notes of excavations and from occasional outcrops. It crosses the Rideau river a short distance below Porters island, which is composed of the black shales, and thence it keeps across what is known as Sandy Hill or the eastern part of the city, apparently not far from the line of Chapel street. It should cross Theodore street near the intersection of Chapel, the part of the city thence eastward to Cummings Bridge being underlain by the Utica shale which is well exposed along the Rideau at this place. The outline of the formation keeps to the south of Theodore street for about three streets and then turns west towards the canal which it is supposed to cross near Laurier bridge. The shales occupy all the area of the old rifle range, and cross the river east to the Montreal road occupying all the surface through Cyrville and up to Billings Bridge. Area in Ottawa city. Sandy Hill.

In what is known as Centre town, from the crossing of the canal, the Utica shales apparently extend west to the vicinity of Wellington Centre town.

street Thence the northern outline curves to the south-west and the shales occupy the area southward nearly to the intersection of Lisgar with Percy streets. The outline here is limited by the Trenton of Ashburnham hill which is well seen on the line of the Canada Atlantic railway and in several of the sewer excavations in the vicinity. It however should cross the line of this railway between Bank and Kent streets and cross the former near the bridge over Patterson creek, extending thence east for about ten chains and crossing back again about five chains north of the canal bridge, whence it keeps north of the canal to the line of fault east of Dows lake.

Faulted character.

The breadth of the Utica basin about two miles east of the Rideau river is not far from seven miles. Attempts to ascertain the thickness of the formation have been made at several points. While the rocks undoubtedly lie in a broad and probably somewhat shallow basin beneath the Lorraine, the shales are affected by numerous small faults, some of which can be readily seen. These are for the most part merely local, but have made the determination of the actual thickness of the formation largely conjectural.

Fossils.

The characteristic fossils of the Utica are found everywhere throughout the area. At Billings Bridge they may be obtained from the exposures along the small brook in the rear of the village. At the old rifle range, crossed by Chapel street they are abundant in the material excavated for the deep sewer as also at New Edinburgh. They are found also on the Montreal road, at Cyrville and on the Metcalfe road near Leitrim post-office. From most of these places collections have been made by Dr. Ami and by other officers of the Geological Survey which have been tabulated.

TRENTON LIMESTONE.

Trenton limestone.

The areas of Trenton limestone found in this map, though well exposed, are of no very great extent. Their distribution is also largely affected by numerous faults. Generally the strata are in a nearly horizontal attitude or lie in low undulations, but when near the lines of faulting, they are often highly inclined.

Areas.

The principal area is in the city of Ottawa and in Hull, whence it extends to the line of the fault northerly from Tetreauville to the contact with the crystalline rocks. On the west, this formation is bounded by an outcrop of Black River limestone which is seen in the village of Tetreauville, and thence north to Fairy lake, where this fault is well seen.

C. O. Senécal.—Photo. 1901.

TRENTON LIMESTONE.—TABLE ROCK, CHAUDIÈRE FALLS, OTTAWA RIVER.

The northern limit of the formation yet recognized is about two miles north of the Ottawa river, though as this area is in places largely drift-covered, the exact line of the boundary is to some extent conjectural. Northern limit concealed in part.

The formation is bounded on the north by a fault which separates it from the Chazy, and which extends eastward towards the north end of Leamy's lake, where it meets the northward extension of the fault seen on the point east of Governor's bay, near Rockcliffe park. East of this several faults are seen, and the Trenton is cut out for some distance in the direction towards Beechwood cemetery. The limestones again come into view in the cemetery and continue to the Montreal road in a somewhat narrow band with a curving outline to the fault west of Greens creek. The lime quarries of Mr. Robillard are in this formation, which extends south of the road for about twelve chains to the overlap of the Utica shales. Fault. Montreal road.

By the Greens creek fault, the limestones of this formation are probably thrown some distance to the north. East of this they are concealed over a considerable interval by drift, but the area apparently widens, probably through flattening of the strata. The rock again appearing on the road north from Navan, fifty chains from the village, in a somewhat bold escarpment rising from the clay flat northward, and the formation should underlie this flat to a point within two and a half miles of the Ottawa river, where there is a probable contact with the Black River limestone. The area of the Trenton apparently becomes much broader as the township of Cumberland is crossed, occasional outcrops of the limestone being seen. Navan.

Along the Rideau river the Trenton is but slightly developed. The limestones are seen at the Canadian Pacific railway bridge across that stream below the Hogs Back, where they are overlapped by the Utica shales. They are affected by several faults at this place and also at the outcrops near the Hogs Back, where they are in contact with the Black River limestone, just below and above the dam. The structure of the area along this part of the Rideau river is somewhat complicated by these breaks, and the details can only be shown on a map of large scale. Near this place are several large quarries in the formation. Those on the Montreal road have already been referred to, and the principal quarries in Hull are also in these limestones. Areas along the Rideau river. Quarries.

In Ottawa city the southern outlines have already been indicated by the limits of the Utica already described. The cliffs along the south side of the river, as at Parliament hill and Nepean point, as Area in Ottawa city.

well as further east, are also of Trenton limestone. Along the north shore of the Ottawa, between Hull and Tétreauville, the strata are much broken up, especially above the Canadian Pacific railway bridge, and sharp folds with faults are seen on this line of section, which, however, can only be examined at low stages of water. These disturbances are also observed in several of the islands above the bridge and also in Hintonburgh.

Thickness.

The exact thickness of the Trenton limestone in this area can not be definitely made out. In the Geology of Canada, 1863, page 166, it is stated that 187 feet are exposed in Parliament hill. There is near here a fault with a displacement of seventy feet, but the assumption is made that the total thickness of the formation is not far from 600 feet. This is supported by evidence obtained in the area south of the Ottawa river furthur east.

The best exposed outcrops of the formation in the city itself are seen in the western part. The cliffs along Wellington and at the end of Maria streets, with the cuttings along the Canada Atlantic railway, show good partial sections.

Areas in Nepean township.

In the western part of the township of Nepean, these rocks are again exposed. They are separated from the Calciferous which occupies a large portion of the northern half of the township, by a fault which has been stated to continue along the south flank of the ridge of crystalline rocks, through the townships of Huntley and Fitzroy. The characteristic limestones are seen at several points along the Richmond road south of this fault and on several roads north of Fallowfield, and the breadth of the formation here is about two miles.

Huntley.

West of this place they are seen along the roads in the east part of Huntley where they form a belt about three miles in breadth which continues westward into Fitzroy. These rocks represent apparently only the lower members of the formation.

BLACK RIVER LIMESTONE.

Black River limestone.

The limestones of this formation were formerly classed with those of Trenton age, forming their lower portion. As they are however somewhat different in physical character and contain fossils which do not range upward into the Trenton proper, they may now be regarded as a separate division.

New Edinburgh.

On the north side of the Trenton, below New Edinburgh, the limestones of this division are seen in a small area near the line of the

Electric railway below Governor's bay. The area is of limited extent, and though the characteristic fossils of the formation have not yet been collected at this place, the features of the rocks are similar to those observed in other localities where this formation is well developed. These rocks come directly against the Chazy shales at this place and there is an old quarry in a cutting of Trenton limestone to the south of the road.

Beechwood cemetery.

At the entrance to Beechwood cemetery a bluff about thirty feet in height occurs to the east of the road leading to Hemlock lake. The rocks in this escarpment are characteristic Black River limestone. They here dip S. 65° E. $< 7°$. The rocks of the escarpment pass beneath the Trenton which is found inside the cemetery. A fault occurs here which cuts out a part of the Chazy limestone in the direction of Hemlock lake.

From this point the band of the Black River limestone continues east, keeping to the north of the Trenton outcrop in the direction of Greens creek. It is seen in a low escarpment to the north of the road past Robillard's quarries, near the summit of the rise adjacent to the line of the Greens Creek fault.

Dislocations.

By this fault the formation is supposed to be thrown to the north about twelve chains ; but east of this place it continues across Greens creek and is seen at the end of a short road on the concession line south of the Montreal road between lots 10 and 11.

Blackburn.

The limestones also appear along the road between ranges II and III, east of Blackburn post-office, where they form broad ledges for nearly a mile in an eastward direction.

Cumberland township.

East of this again toward Cumberland the band gradually widens, probably from flattening of the strata. There is a somewhat sharp bend to the north at the crossing of the township line between Gloucester and Cumberland, and here the formation approaches the Ottawa to within a mile of the shore. The breadth of the Black River formation here is about one mile.

Extension north of the Ottawa river.

North of the Ottawa the small area which has been noted as occuring at Rockcliffe park, where it is cut off by a fault, presumably extends north-westerly, crossing the Gatineau, though here concealed by drift, and terminating against the fault which is supposed to strike south from the north end of Leamy lake.

Tétreauville.

West of Hull these limestones again appear in Tétreauville near the same line of fault, the strata being much tilted and broken near

the contact. The dip of the strata at this place is N. 55° E. < 45°--50°. Northward the formation extends west of the Beaver meadow showing in broad ledges north of the Aylmer road, in the direction of Fairy lake. Further west it rests upon the Chazy limestone of the area east of Aylmer.

Area north of Aylmer.

North of this place and capping the ridge there is an outlier, about two miles in length, by one and a half in breadth, of roughly oval shape. The rocks at this place pass upward into the basal beds of the Trenton proper, *Receptaculites* being found in the highest portion.

Areas south of the Ottawa river.

South of the Ottawa river the continuation of this area, after crossing the river into Mechanicsville, where it is seen along the west side of the deep inlet near the Little Chaudière rapids, continues in a widening belt to the line road between the river range of lots and

Hintonburgh.

those in Nepean proper near City View. The rocks apparently underlie the whole of the Experimental farm west of the Ottawa and Prescott branch of the Canadian Pacific railway, and are well exposed to the west of Hintonburgh near the main line of the Canadian Pacific in broad ledges. They form a bold escarpment to the north of City View post-office and are also exposed in a bluff to the south of that place in which a small quarry is located. Here they rest conformably upon the Chazy limestones.

Richmond road.

Along the south shore of the Ottawa river they occupy a breadth of about half a mile west of Mechanicsville. Thence they extend across the Richmond road, their contact with the underlying Chazy being about three-fifths of a mile east of Westborough.

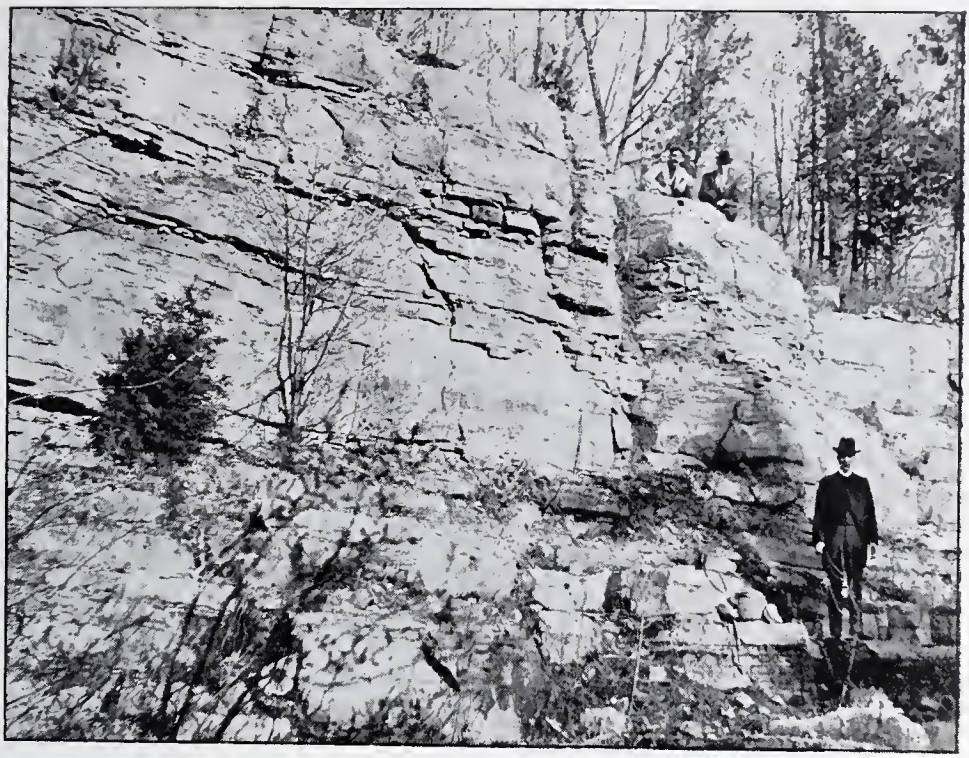
Hogs Back.

Near the Hogs Back these limestones also appear in a narrow outcrop on the east side of the dam in contact with the fault at this place, and on the hill-side to the south. In this knoll to the south, several hundred yards distant, their contact with the Trenton can be

Areas south of the Rideau river.

observed. South of this they can also be seen at several points on the road up the east side of the Rideau river, more particularly in an old quarry on lot 3, of the second range facing the river, where the fossil *Tetradium* is abundant. They again appear on the straight road between ranges II and III, on lots 3 and 4, in an escarpment with an old quarry and in broad ledges in the fields adjacent, and also on lot 23 of the Junction gore near the Rideau river, east of Hogs Back.

Heavy faults occur in this area and they have affected the horizontal extent of the formation.



H. M. Ami.—Photo. 1900.

BLACK RIVER LIMESTONE.—CLIFF NEAR ENTRANCE TO BEECHWOOD CEMETERY, OTTAWA, ONT.

H. M. Ami.—Photo. 1900.

CHAZY SHALE AND SANDSTONE IN EXCAVATION AT BRITANNIA POINT, NEPEAN TOWNSHIP, CARLETON COUNTY, ONT.

In the eastern part of the area covered by the map these rocks are not seen, but they again come into view to the east of Russell village.

CHAZY LIMESTONE.

Chazy limestone.

A separation has now been made between the limestones of the Chazy formation which form its upper portion and the shales and sandstone which constitute the lower member. The principal area of the former is found in the western part of the map-sheet north of the Ottawa river from Tétreauville westward. They are concealed over a large portion of their development by heavy deposits of clay and sand, but are supposed to extend north from Aylmer, with a breadth of three miles and a half, or nearly to the foot of the ridge of crystalline rocks which form Kings mountain and its extension to the north-west; while from east to west they occupy the country for about ten miles or from Tétreauville nearly to Breckenridge station, on the Pontiac and Pacific Junction railway.

Aylmer and vicinity.

Tétreauville west.

Along the north shore of the Ottawa the limestones appear from beneath the Black River formation in nearly horizontal strata and continue along the shore from a point just west of Tétreauville, for a mile and a half to the underlying shales.

Deschènes and Aylmer road.

West of this with a curving outline the southern margin should cross the road from the Aylmer road to Deschènes, about midway between the latter road and the Electric railway. Thence the outline continues north-west and crosses the Aylmer road three-fourths of a mile east of the town of Aylmer, and the contact with the shaly portion of the formation is seen on the road north of this place at about the same distance from the main street.

West of Aylmer.

The course of the contact with the shales is thence apparently quite straight for several miles. It crosses the road leading up the north side of the Ottawa near the crossing of the Eardley township line, and, keeping a few chains to the south for a couple of miles, it crosses again to the north of this road and the outcrops disappear beneath the drift.

Contact with Chazy shales.

The contact of the sedimentary rocks with those of the mountain range to the north is not directly seen at any known point. It is impossible therefore to say definitely whether this contact with the granite is by a fault or not, but this seems to be the case, since along the river near Breckenridge the Chazy shales are in contact along the shore, as far as can be ascertained, with the granite, while further

west the Calciferous and Potsdam sandstones appear again near the village of Quyon.

The most easterly recognized outcrop of the limestone of the formation of this area is near the brick and tile works on a small creek which crosses the road between lots 8 and 9, ranges III, and IV., Hull township. Fossils are found in these rocks which are dolomitic. This point is about one mile south of the crystalline rocks and the lower shales appear in a small brook twenty-five chains north.

Areas south of the Ottawa river.

The Chazy limestone of the area west of Tétreauville crosses the Ottawa river in a band with a surface breadth of about one mile. On the south side of the river it contains the large quarry from which the cement stone for Mr. Wright's works is obtained. The limestones are in low undulations at this place with dips of two to three degrees. The quarry is rather more than half a mile from the end of the road to the river at Mechanicsville, above the Little Chaudière rapids. The western line of the formation is seen near the point on which the old Skead mill was situated, where it passes down into the shales.

Westborough.

Thence south the limestone band occupies a considerable area along the Canadian Pacific railway and is seen about Westborough. Good exposures are visible on the road leading south from this place in an escarpment cut through by the Electric railway, the dip not being more than two degrees to the south. They form an area rather more than a mile in breadth to the south-west of the Black River outlier at City View, and follow that outcrop round by the south, turning to the east again and coming to the Rideau river, below Hogs Back, where they are exposed below the dam and in the bed of the stream near the road crossing; they are here fossiliferous and presumably represent the transition beds between the shales and limestones.

Hogs Back.

Contacts.

East of the Rideau river a small area occurs near the line of the Hull and Gloucester fault, overlain by the Black River limestone. The Chazy limestone apparently terminates along this break at a point about three miles and a half south-east of Hogs Back. It is also seen at the corner of the road between ranges II and III, with that west from Chaudière Junction. Here there are several faults and the limestone is exposed along the road south in cuttings and in the hills on either side. The inclination of the Chazy near this place is about eighty degrees, the contact with the Utica shale being on the east.

Russell.

The Chazy limestone is not seen in the eastern part of the map-sheet except along the Montreal road already described. It however outcrops along the Castor river at the village of Russell a short distance

east of the limit of the sheet and here contains the characteristic fossils of the formation.

CHAZY SHALES.

Chazy shales.

The shales which form the lower part of this formation are generally grayish in colour with shades of green and have a sandy texture. Occasionally beds of sandstone occur, and these become a coarse grit at the base. Reddish shades are seen in the shales along the Ottawa river at several points, with interstratified thin bands of limestone in the upper portion. They form a well defined belt of sediments resting conformably upon the Calciferous, the upper member of which also becomes shaly in certain areas. Some of the limestone bands in the Chazy are almost indistinguishable in character from certain portions of the Calciferous dolomite.

As a rule the shales are in a nearly horizontal position, but near the lines of fault they are often highly inclined as in the outcrops below Hogs Back and to the south.

Rockcliffe park.

East of Ottawa city these shales can be well seen on the south shore of the river at Rockcliffe park and for several hundred yards to the east and west of the Gatineau ferry, where they form a cliff along that part of the Ottawa, extending to the old wharf in the clay flat at the east end of the park. They here form an area of about three fourths of a mile in width till they are overlapped by the limestones. They are well exposed about the west side of Hemlock lake and also on the several roads leading south from the river to the Montreal road.

Montreal road below Greens creek.

Although the south shore of the Ottawa below Rockcliffe park is clay-covered, it is supposed the shales occupy most of the area nearly to Cumberland village. In the area west of Greens creek they are concealed by clay, but they again appear along the Montreal road below Greens creek, the contact with the limestone keeping near this road for several miles eastward. At Orleans village they appear in a small brook north of the road and are capped by the limestone which shows in a hill between this and the river. Thence on the road to Cumberland they may be seen at intervals and are well exposed in the escarpment south of the latter village. Near the wharf they rest upon Calciferous dolomites and shales.

Deschênes.

West of the city and north of the Ottawa they come into view on the shore about two miles east of Deschênes mills. They are well exposed along the line of railway to Aylmer in numerous cuttings, the

Aylmer.

strata being nearly horizontal. Thence they form a band nearly one mile in breadth past the town of Aylmer where they are well developed and continue westward as a narrow belt to the cove below Breckenridge station. At the Aylmer Electric park they are bounded on the side next the river by a narrow margin of the Calciferous which extends west from the Cedars for several miles. Along the road west from Aylmer and also on the Pontiac and Pacific railway exposures are numerous.

Westborough and Britannia.

South of the Ottawa the eastern limit of this area appears at the point by the old Skead mill at Westborough. The shales are seen along the shore west of this place past the village of Britannia where they are well exposed and the new excavations for the Metropolitan Power company are in this rock at Britannia point. Cuttings in the shale are also seen along the line of the Canadian Pacific and Electric railways. Fossils are sometimes found in calcareous bands in these shales, and collections have been made in the rocks about Aylmer especially by Mr. T. W. E. Sowter.

About half a mile above Rocky point, which is on the west side of Britannia bay, two miles west of the village, the shales are probably in contact with the underlying Calciferous, since the latter are exposed along the beach at several points a short distance further west.

South of Britannia the shales and sandstones occupy a considerable area. Along the line of the Canada Atlantic, (O., A. & P. S. railway) they are seen near the crossing of the Richmond road whence they apparently bend to the east and form a belt a mile in width extending to the Rideau river. They show on the road from City View to Merivale and there is an outcrop seen at low water on the Rideau river about one mile below Black rapids. The area of the shales increases in width as the Rideau is approached, and on this stream it has an apparent breadth of several miles or from below Hogs Back to the contact with the Calciferous above that locality. At the former place its extension eastward is terminated by the fault from Hogs Back which extends along the east side of the river below the dam, and the anticlinal there is in the upper portion of the formation.

South of City View.

Rideau river.

South of Hogs Back.

Further south the shales are seen on the road between ranges II and III of Rideau Front, where they are concealed southward by the limestone, but they are supposed to come to the surface again about two miles further south and should reach the prolongation of the Hull and Gloucester fault about lots 10 and 11 of the fourth range.

Thickness.

The thickness of the two divisions of the Chazy may be stated as about 110 feet for the shales and 100 feet for the limestone.

Calciferous and Potsdam.

There is no break between the Calciferous which is for the most part a dolomitic limestone, and the Potsdam which is a sandstone. There are from twenty to thirty feet of transition beds in which the sandy part of the latter becomes more calcareous and it is from this portion that most of the fossils which have been described as Potsdam have been obtained.

East of Ottawa city on the south side of the river the Calciferous rocks do not appear at the surface till within a short distance of the village of Cumberland. It is supposed however, that following the sinuosities of the Chazy a narrow margin rests upon the south shore in the vicinity of Greens creek though the thick deposits of clay have effectually concealed the rock outcrops.

Templeton areas.

On the north side however the characteristic dolomitic limestones of the formation are exposed at several points, notably in the vicinity of East Templeton and along the road westward to near Wabassee creek. They here form broad ledges for some distance, with a low dip to the south. They pass downward into sandstones of Potsdam age which form a prominent escarpment about 700 paces south of the Canadian Pacific railway west of Templeton station, and the contact with the crystalline rocks is seen on the branch railway leading to Templeton mills on the shore, where they have a dip S. to S. 5° E. $< 5° - 7°$. This changes in the village on the main road to S. 50° E. $< 5°$.

Probable extension.

Directly east of the Gatineau these formations are supposed to occupy the flat clay-covered area to the foot of the ridge of crystalline rocks and to terminate westward against the Hull and Gatineau fault.

Electric park Aylmer.

West of the Gatineau river the only outcrops of the Calciferous are seen along the Ottawa west of Aylmer. They are first observed along the Electric railway near the Cedars and in the Electric park they extend inland nearly to the line of the Pontiac and Pacific Junction railway where they are overlain by the Chazy shales. The Calciferous thence continues westward in a narrow strip following the shore and is seen in contact with the Chazy on the road along the Hull and Eardley line about three chains south of the railway crossing.

Areas south of the Ottawa.

South of the Ottawa the area is much more extensive. The dolomites occupy all the shore at the point north of Shirley bay to the contact westward with the base of the Chazy about one mile and a half from that point. Eastward of the bay they are seen along the

shore at a number of places to their contact with the shales west of Rocky point.

Bells Corners.

Southward they have a breadth of about four miles to the line of the Nepean and Huntley fault, north of Fallowfield, and in this vicinity the limestones pass down into the sandstones which are well seen on the roads south of Bells Corners. The sandstone also surrounds the eastern end of the ridge of crystalline rocks, consisting of granite, gneiss and limestone with diorites, seen along the Canada Atlantic (O. A. & P. S. Ry.) in the vicinity of South March station. These formations are bounded on the south by the extension of the Huntley fault eastward to the line between ranges III and IV of Nepean. Thence they apparently occupy the entire country to the Rideau river near Black rapids, and extend southward along that river from near Black rapids lock, including the greater part of the township of Nepean, the whole of North Gower and of Osgoode and the country south to the St. Lawrence at Prescott. Ledges seen on a brook near the Black rapids lock dip N. 70° E<5°.

Rideau river.

Black rapids.

Hull and Gloucester fault.

East of the Rideau they are much overlain by drift, but form an apparently unbroken area to the Hull and Gloucester fault where on lot 14, range IV, Rideau front, they dip N. 35° E.<65 though near by the dip is to the S.W.<5°.

Potsdam of Nepean.

The underlying Potsdam which appears along the east end of the granite ridge in the western part of Nepean forms a considerable rise, and here are located several quarries from one of which much of the stone used in the construction of the Parliament and Departmental buildings in Ottawa was obtained. Some of this stone is sufficiently free from iron to be used for glass-making and a large quantity is said to have been recently shipped for that purpose.

The breadth of the Potsdam area at this place is about two miles. Along the north flank of the granitic ridge it extends through the south part of the townships of March and Torbolton, but disappears near the south line of the latter about five miles east of Fitzroy Harbour probably by a fault, since from this point westward the Potsdam is not seen on the north side of the ridge, but appears in a small patch only at the summit on the road north from Kinburn on lot 11, range X, of the township of Fitzroy.

Contact with granite.

Along the line of the Canada Atlantic, (O., A. & P. S. Ry.) near the east line of March township there is a cutting in these sandstones. Here the granite also appears, having broken into the sandstone, the

contacts being well seen and the latter being somewhat altered, while the granite becomes very quartzose. The Potsdam at the contact is tilted and dips S. 50° E. <15°–20°. In the vicinity the sandstones are filled with Scolithus markings which are the only fossils yet recognized in this part of the formation in this district.

CRYSTALLINE ROCKS.

Archæan north of the Ottawa.

The crystalline rocks found in the area of the map are mostly confined to the portion north of the Ottawa river in the townships of Hull and Templeton. They have been described to some extent in earlier reports, notably in that by Mr. Vennor for 1876–77, and in the Geology of Canada, 1863. On the south side of the river they are represented by the rocks of the ridge which extends east from Arnprior to within nine miles of Ottawa city. In this ridge which is largely composed of reddish granite and a coarse blackish diorite, limited outcrops of limestone are seen, and likewise of reddish and grayish gneiss, some of which is highly garnetiferous. At a point 100 yards west of South March station the gneiss dips S. 10° E. <75°.

Ridge near South March.

Characters of the rocks.

The area north of the Ottawa is extensive and forms the southern portion of the great Archæan complex of crystalline rocks, formerly styled Laurentian or the Grenville series. They consist of reddish, gray and dark gneisses with numerous and sometimes large bands of crystalline limestone, and these are cut by numerous intrusives, including granite, pyroxene, diorite, diabase, pegmatite, etc. Some of the gneiss is of the variety known as sillimanite.

Kings mountain.

The most prominent feature in this area is the great ridge known as Kings mountain which has an elevation of about 1,100 feet above sea-level. It extends westward for some miles with a bold front facing the great flat which occupies the north side of the Ottawa river, as far west as the rear of Quyon. An area extends south-eastward from Kings mountain to a point on range IV., lots 8 and 9, of Hull township. From this point the eastern front of a ridge keeps to the west of a road which leads from Hull past the Forsyth iron mines to Old-Chelsea, the country eastward to the Gatineau being heavily clay-covered. Along the road from this village to the Gatineau at Chelsea, crystalline rocks consisting of limestone, gneiss and granite are seen. The exposed crystalline rocks thus approach Hull in a long narrow ridge from the north-west to within a mile and a half of Tétreauville.

Area north of Hull.

Area east of the Gatineau river.

East of the Gatineau river large areas are also clay-covered. Ridges of the crystalline rocks, however, show at or near the old crossing at Wrights Bridge and also near Wabassee creek, whence they extend to Templeton station on the Canadian Pacific railway. Beyond this they are again largely concealed by drift to the eastern margin of the map-sheet.

That the granite and gneiss underlie a large part of this area is probably from occasional outcrops in the beds of several of the streams, as on the upper Blanche river so that presumably the greater part of the area is underlain by these rocks.

Limestone bands in Hull township.

The general strike of the gneiss both east and west of the Gatineau is north-east. The dips are sometimes reversed indicating anticlinal structures. Of the limestones several well defined bands are visible. The most extensive of these yet recognized in the district is seen on ranges VI. and VII. of Hull, along what is known as the Mountain road which leads in a north-west direction along the south-west flank of the ridge of crystalline rocks. The limestones are exposed on the west side of this ridge from lots 14 to 19, with a breadth on the road of about two miles. North-eastward on the strike the band diminishes in width, and on the road to Old Chelsea, north from the iron mines, it is scarcely more than half a mile across. With the limestones are associated masses of granite, sometimes reddish but more generally white in colour and in the form of pegmatite dykes.

Band near Forsyth iron mine.

A second band of limestone occurs on lot 12 on the Mountain road and extends north to the Forsyth mine which is located in this belt. On the road past the iron mines it has a breadth of a little more than a mile, and is separated from that just described by an area of granite and gneiss, a fourth of a mile in width.

Small irregular areas of the limestone are also seen on the Mountain road, south of Kingsmere, on lots 20 and 21, but their extension northward is affected by masses of granite and pyroxene in which are located several important mica mines.

Old Chelsea bands.

On the road from Old Chelsea east, several small outcrops of the limestone are seen, but their areas are small and irregular, their distribution evidently being influenced by granite masses. On the road north-east from Old Chelsea to Kirks Ferry a narrow band of the limestone occurs which widens out at the Gatineau to nearly half a mile. This band crosses the river in the direction of Cantley, where it is seen on the road to Wilsons Corners.

East of the Gatineau there are also several other small bands. The most important of these traverses ranges IX., X. and XI. of Hull township, from lot 2, to lot 8, where it comes to the east bank of the river. A small and local outcrop is also seen on the east side of the river on lot 7, range VIII, and further south a larger band appears near Wrights Bridge, and extends north-easterly for about a mile, though what may be a narrow extension of the same is visible near the post-office of Quinnville. Limestones east of the Gatineau.

The eastern part of the sheet, where not covered by drift, is largely occupied by gneissic and granite rocks. Several small and narrow bands of the limestone occur to the east of the Blanche river, in range IV. of Templeton, which extend probably towards Donaldson lake, west of Buckingham, beyond the limits of the map.

The area in the north-west angle of the map, in the direction of Meach lake, is largely granitic. In places this rock is foliated, but over a considerable extent this feature is lacking. Meach lake.

Mines of mica, apatite, iron, baryte and felspar are found at points throughout the district which will be described under the head of economic minerals.

ECONOMIC MINERALS.

The mineral deposits found in the crystalline rocks north of the Ottawa have been known for many years. Some of them have been referred to in early reports of the Geological Survey, and have been described in various papers to the scientific journals. Economic minerals.

They include mica, apatite, graphite, asbestus or chrysotile, iron ores, baryta, felspar. In addition, however, there are other economic deposits found in the Palæozoic formations which are also of great importance, such as the limestones of Chazy and Trenton age, which have been largely used for building stone and for lime and cement, the shales of the Utica which form an excellent stone for roadmaking, the granites and diabase rocks well suited for macadam, the overlying brick clays which occupy a large area, shell marl, mineral waters, etc.

MICA.

Of the minerals found in the older rocks probably the most important at the present time are the deposits of mica. Along the Gatineau, in a belt several miles in breadth on either side of the river and ex- Mica deposits.

tending northward for more than one hundred miles, this mineral is found, often in such quantity as to be of great economic value.

Kingsmere mines.

Among localities in the limits of the map may be mentioned several mines situated about one mile south of Kingsmere. The principal deposits at this place are owned by Brown Bros., of Cantley, by Mr. Fleury, of Kingsmere, and by Fortin & Gravel.

The mica at all these mines is found in masses of pyroxene which cut the gneiss of the district and form part of a prominent hill which slopes abruptly to the Mountain road. The mica is developed in irregular fissures in the pyroxene and also near the contact of this rock with the inclosing gneiss. The interspaces have been filled in many places with calcite which is often pinkish in colour, but in some of the mica mines this calcite is almost or entirely wanting. The location of the Brown mines is on lot 18, 19 and 20, ranges VI. and VII., of Hull. The Fleury mine is on lot 20 of range VII., and the Fortin & Gravel on lot 18, of the latter range.

Gemmill mine.

Another well known mine is located on lot 10, range XII. of Hull, on the east side of the Gatineau river. This is known as the Gemmill or Vavasour mine. It is situated in a hill of pyroxene rock with granite which cuts the red gneiss of the area. In one of the pits at this place there is a dyke of pyroxene about eighteen inches wide, the centre of which is occupied by apatite about six inches thick. This dyke cuts red gneiss. Apatite also occurs in crystals in the calcite with which most of the mica is here associated. This mine has been worked regularly for some years and has a depth of fully one hundred feet. The output of mica has been large and of excellent quality, being an amber or phlogopite variety.

Several small but apparently unimportant shows of mica occur along the road leading to Cantley but have not been developed to any extent.

Nellie and Blanche.

One of the largest mines in this area, at one time extensively worked, is that known as the Nellie and Blanche, on lots 9 and 10, range X., Hull. The mica occurs in a large mass of pyroxene in fissures rather than as a contact deposit, as is the case with many of the mines in the Gatineau district, Though it has been idle for the last seven years it was opened to a depth of 170 feet and yielded a large quantity of large and clear crystals of the phlogopite variety, though much of the output was of small size. A small quantity of apatite is found in the workings.

On lot 1, range XII., is located an old mine worked formerly for apatite and known locally as Burke's. The mica is here associated with the apatite in a pyroxene dyke which cuts the gneiss of the district, and there is a large amount of calcite. One very large crystal of pyroxene was observed in the side of the opening. In the dumps around the mine mica was seen in good sized crystals, and a large quantity had evidently been taken out which at the time of working was regarded as a waste product and so has been spoiled by long weathering. This place has been unworked for some years. Burke's mine.

On the west side of the Gatineau, in addition to the mines mentioned near Kingsmere, several other deposits of mica are found, Among these may be mentioned those to the north of Old Chelsea and about Kirk's Ferry. This area is an interesting one for the study of contacts and the mineral is found at a number of points.

In the hills west of the Old Chelsea brook which flows past Chamberlain's house at that village, the country-rock is for the most part a banded red and gray gneiss, in places with black bands. These are cut by many dykes of pyroxene and granite, the former carrying sometimes small quantities of dark mica and considerable deposits of red apatite. At one point there is a great mass of pyroxene crystals generally of small size. The quantity of mica as yet found in this hill is not large. Old Chelsea.

A little further along the road to Kirks Ferry and a little west of it is the Scott mine. The rock here is also a reddish gneiss and a dyke of pyroxene cuts across the strike carrying crystals of red apatite and amber mica. The gneiss strikes north-east and dips to the south-east. The amount of mica found here is also small owing probably to the small size of the pyroxene mass.

In the Scott north pit the banding of the gneiss is well defined and there is also a dyke of pyroxene, in places running nearly with the strike of the gneiss. The mica here is a light amber variety and some good sized crystals were obtained several years ago, about ten tons having been taken out in 1893, some of which was badly wrinkled. Other dykes of red granite and of pegmatite also occur here and in one of the openings a beautiful red jasper is found, parts of which when polished make a beautiful ornamental stone Red apatite is also seen. Scott mine. Jasper.

Among other localities where mica is found in small quantity in this vicinity may be mentioned lot 15, range X., Hull, in pyroxene cutting gneiss, and lot 17, same range, in pyroxene and calcite, with a Mines near Old Chelsea.

small quantity of green apatite. Some of the pyroxene in this area is almost black, in which case the contained mica becomes very dark-coloured, and as a rule it may be stated that the darker the containing rock the blacker the mica.

In the hill back of the Old Chelsea church the reddish and gray gneiss is also cut by pyroxene dykes. An opening here shows many small crystals of dark mica, and there is also at this place a small exposure of rensselarite similar to that found at the corner of the road to Kingsmere near Chamberlain's house. Near this corner the crystalline limestone outcrops in large ledges and in certain portions there are small irregular veins of chrysotile with serpentine, apparently of no economic importance. The serpentinized limestone resembles the rock at the asbestus mine near Perkins Mills back of Templeton. Numerous small dykes of dark diabase also occur in the rocks of this area.

Serpentine.

On the road to Kirks Ferry the limestone is cut by small dykes of pyroxene and small crystals of mica, smooth and of good colour are seen at several points. These have been worked to a limited extent but the quantity of mica appears to be small.

At Kirks Ferry several mines have been opened and worked. Among these are Haycock's old mines on lots 12 and 13, range XI., Hull township. Some fine crystals have been obtained from these places, but work ceased several years ago. The mineral occurs in the usual way in pyroxene which cuts the gneiss. The latter strikes north-east with a south-east dip. Bands of limestone also occur in the vicinity, and in a cutting on the Gatineau Valley railway in front of the falls on the river, the contact of several intrusives can be well studied. In this cutting a vein of mountain cork was found several years ago but this has apparently been all extracted.

Kirks Ferry.

Mountain cork.

In the mica pit west of the road, several dykes are found. Calcite occurs with the mica and fine aggregations of crystals of mica and pyroxene can be obtained. At one of the openings the pyroxene in the cutting is capped by the gneiss.

On lot 14, range XI., of Hull, (Connors' mine), banded red and gray gneiss occupies the side of the ridge facing the Gatineau river. This is cut by small cross dykes of pyroxene from one to three feet wide, which carry mica in numerous small crystals, much of which is, however, badly crushed. At the contact of two small dykes many small crystals of red apatite are seen with others of greenish shades. Small quantities of red apatite are also found in nearly all the openings. At

Connors' mine.

one pit near the north end of the location, mica from ten to twelve inches in diameter was observed, but no pink calcite was seen at this place.

Snow's mine.

On lot 14, range XII., a short distance above the toll-gate north of Kirks Ferry, there is also a mine in pyroxene cutting gneiss, owned by Mr. Snow, of Ottawa, from which several hundred tons of apatite were taken. Mica is also found here and at several places in the vicinity, but these deposits have never been developed to any extent and their value is therefore, at present, uncertain.

The above descriptions of the mica deposits are believed to cover the principal mines in the district included in the map-sheet. Several large and valuable mines, however, lie along the course of the Gatineau a short distance to the east and west as at the Cascades and near Wilsons Corners, but as they are not included in the map, need not be here described.

APATITE.

Apatite.

While this mineral is found in connection with the mica at nearly all the mines in the district it is not in sufficient quantity at any observed place to make its extraction, as an individual product, profitable. In mining the mica, it is however taken out and saved, and will thus be an important asset should the market price advance sufficiently to render its handling practicable.

There does not appear to be any of the great pockety masses such as occur in the Lièvre district at High Rock and other points in the vicinity. The mineral in the Gatineau district usually occurs as crystals in the calcite with which the mica is frequently associated.

Mode of occurrence.

McRae's mine.

This mineral, as a rule, occurs in pyroxene dykes, often of large size, which cut the gneiss and sometimes the limestone of the Grenville series in all directions. The principal localities at which it has been found along the Gatineau have been described in the preceding chapter on mica, but there is one other place at least where apatite was extensively mined some years ago, on lot 11, range V., Templeton township, known as the Electric or McRae mine. The country-rock here is a grayish, often quartzose gneiss, with a strike N. 25° E. dipping west $< 80°$, and this is cut by a large dyke of pyroxene at right angles to the strike of the gneiss. Much work was done by the installation of an electric plant for drills, lights, etc., and the excavation is large. Other dykes of pegmatite occur about the mine, but the apatite, which

was found in large quantities, was confined to the pyroxene, and occurs, as is generally the case, near the contact with the enclosing gneiss Borings with a diamond drill at this place were made to a reported depth of 176 feet in the dyke, and the mineral is said to extend to the bottom of the bore-hole. Work has been discontinued at this mine since 1892, owing to lack of market for the output.

IRON ORES.

Iron ores.

Important deposits of iron-ore are found in the township of Hull, some of which have been worked quite extensively. Of these, probably the best known are the Forsyth and Baldwin mines on lots 11 and 13 of range VI., about two and a half miles west of Ironsides village, and the Haycock mines on lot 1, range XI., of Hull, and lot 28, of range VI., of Templeton township.

The early history of these mines will be found in the report on the "Economic Minerals of Quebec," Annual Report, 1888-89, pages 8-12 K. The Forsyth and Baldwin mines occur in the belt of limestone which crosses ranges V., VI., and VII. Of these, the former is on lot 11, and is that from which the ore was chiefly taken. The Baldwin is on lot 13, and has apparently never been well developed. There is a new deposit on lot 12 which has recently been partly prospected by the Messrs. Hibbard, but the value of the deposit does not yet seem to have been fully proved. These iron outcrops are presumably all on the continuation of the same fissure.

Forsyth mine.

At the Forsyth mine there is a large body of mixed ore, principally magnetite of good quality, with some hæmatite, which fills an irregular fissure in the crystalline limestone, and runs a little north of west. The cutting in the old workings extends west of the road to Old Chelsea for twelve chains. In places it reached a depth of over 100 feet, and the ore-body was found to be somewhat irregular in shape, being wide near the surface but diminishing as the depth increased. At the bottom of the main shaft the thickness of the ore is reported at about eighteen feet.

Of the large quantity of excellent ore taken from this place, much was shipped to the United States. A portion was, however, smelted in a small blast-furnace, which was erected near the bank of the Gatineau at Ironsides village. The old furnace was taken down nearly twenty years ago, and no work has since been done at the mine except a little prospecting. The ore contained small quantities of sulphur and phosphorus, but not sufficient to be injurious. There is also a small

percentage of disseminated graphite. Dykes of granite and greenstone are seen in the cuttings, and the ore-body is probably a large pockety or lense-shaped mass. Eastward the extension of the ore cannot be traced owing to the presence of the clay deposits, but it has here probably been largely denuded.

The ore at the Haycock location is also a mixture of magnetite and hæmatite. The quantity visible has not been found to be as large as at the Forsyth mine, but considerable work was done at this place from twenty-five to thirty years ago and a small forge was erected, the ruins of which still remain. The country-rock is a mixture of granite-gneiss and diorite, and the ore is irregularly distributed. Iron ore is also reported from lot 2, range X. of Hull, but in so far as known has never been developed. Haycock mine.

BARITE.

This mineral occurs in considerable quantity on lot 7, range X, of Hull. It was worked to some extent thirty years ago and was then known as the Foley mine. The vein of barite varies in width from one to two feet and has been traced north-westerly for over 100 yards. It has recently been reopened by a Montreal paint company and a large amount of the mineral has been shipped to that city. Fluorite occurs with the barite in considerable quantity. The enclosing rock is crystalline limestone which is cut by several dykes. Another outcrop of this mineral is seen near the back road on lot 4, range XII., but this has been opened to a very limited extent. Barite. Foley mine.

FELSPAR.

Felspar occurs as an ingredient of the pegmatite dykes which are very numerous in the Archæan area. It is sometimes found in sufficient quantity to be of economic value, but generally there is a percentage of iron which renders it unfit for the manufacture of pottery, and often the felspar is so intimately mixed with quartz that the separation is impossible. Felspar.

It has been mined at two localities north of the Ottawa river. Of these the principal location is north of the Canadian Pacific railway about half a mile west of Templeton station. The other is on the road leading back from Gatineau point and about six miles from the line of railway. Occurrences.

The mineral is generally reddish in colour due probably to a very small percentage of iron in its composition, but this passes off when the

rock is burned, and the resulting product is perfectly white. There is always a certain amount of generally white quartz in the dykes. The expenses of shipment to the United States market are such as to leave but a small margin of profit. Work ceased at both these places several years ago.

South March. On the south side of the Ottawa, a short distance south of March station on the Ottawa and Parry Sound railway, there is also a deposit of felspar, the quality of which appears to be excellent. This place is a short distance beyond the western limit of the map-sheet.

STRONTIANITE.

Strontianite of Nepean. This mineral is rarely found in Canada. On the south shore of the Ottawa river a short distance below the road leading down to the old Skead mill, on lot 31, concession A, of Nepean township it occurs in the form of veins, traversing the lower part of the Chazy limestone, which vary from four to six inches in width. The mineral occurs below high water line and thus can only be seen at a low stage of water in the river. It is referred to in the Annual Report of the Geological Survey, vol. vi., 1892–93, p. 23 R, where it is thus described :

"The mineral, which entirely fills the veins, has a radiating crystalline massive structure, the foci of the several divergent groupings being at either wall of the vein, the radial structure of each group extending thence inward, meeting and interlacing at their extremities with those of the similar groupings of the opposite side of the vein—or, failing that, as was occasionally found to be the case, and in the cavities thus formed, terminating in radiant groups of acicular crystals of from five to nine millimetres in length. Colour, pale yellow-green, shading into white ; translucent ; specific gravity, at 15·5° C. 3·704.

Analysis. The analysis of the mineral by Mr. Johnston upon carefully selected material, consisting of crystals dried at 100° C. gave :

Carbonic acid	30·54
Strontia	65·43
Lime	3·38
Insoluble	0·17
	99·52

"Strontianite, strontium carbonate, is of economic importance by reason of its employment for the manufacture of strontium hydrate, which is largely used in the preparation and refining of beet-root sugar, and in the extraction of crystallisable sugar from molasses. It is also employed for the manufacture of strontium nitrate, a salt much used in pyrotechny." (Page 31 R, same report.)

Among the Palæozoic rocks the principal economics are confined to the limestones. These, especially in the Trenton formation, have been quarried extensively, both for building stone and for lime-burning. The largest quarries now operated are in the city of Hull, near the line of the Canadian Pacific railway, a short distance east of Hull station, and at Robillards, on the Montreal road about three miles from Cummings bridge. Many old quarries are found which have been abandoned for some years. Large quarries are also found near Hogs Back on the east side of the Rideau river. All these are in the Trenton formation. Limestone quarries.

Among the largest in the Chazy is that known as Wright's cement quarry on the south side of the Ottawa above Mechanicsville.

Several analyses of these limestones have been made in the laboratory of the Geological Survey. (See vol. VI., 1892–93, p. 34R.) Of these the following may be given :

Wrights quarry (formerly Mahoney's) Ward No. 1, city of Hull, from the uppermost bed. This has a thickness of two feet. The material of the same, which is much broken, is chiefly, if not exclusively, used for the manufacture of lime. Hull limestone.

Structure, somewhat fine-crystalline ; colour, faintly brownish ash-gray. After drying at 100° C.,—Hygroscopic water = 0·14 per cent, it gave :

Analyses.

Carbonate of lime		97·66
" magnesia		1·38
" iron		0·16
Alumina		
Silica, soluble		0·67
Insoluble matter		
		99·87

From the third bed, thickness of the same, one foot three inches. The stone employed for building purposes. Structure, somewhat finely crystalline ; colour, bluish-gray. After drying at 100° C.,—Hygroscopic water = 0·09 per cent, it gave :

Carbonate of lime		96·25
" magnesia		2·18
" iron		0·32
Alumina	0·95	
Silica, soluble	0·07	1·33
Insoluble matter	1·21	
		100·08

From the fifth bed, thickness of same, one foot two inches. Stone employed for building purposes. Structure, fine-crystalline; colour, bluish-gray. After drying at 100° C.,—Hygroscopic water = 0·07 per cent, it gave:

Carbonate of lime		96·19
" magnesia		1·72
" iron		0·26
Alumina	0·05	
Silica, soluble	0·09	1·74
Insoluble matter	1·60	
		99·91

From the tenth bed. Thickness of same, one foot six inches. The stone employed for building purposes. Structure, somewhat coarsely crystalline; colour, faintly brownish ash-gray. After drying at 100° C..—Hygroscopic water = 0·08 per cent, it gave:

Carbonate of lime		96·92
" magnesia		1·59
" iron		0·25
Alumina	0·07	
Silica, soluble	0·02	2·06
Insoluble matter	1·97	
		100·82

From an outcrop of the Chazy limestone on the south-western side of Hemlock lake in Rockcliffe park, an analysis was made by Dr. Hoffmann, as follows:—

A very fine-grained and compact greenish-gray, yellowish-brown and reddish-brown weathering, massive limestone. After drying at 100° C.,—Hygroscopic water = 0·98 per cent, it gave:

Chazy limestone of Hemlock lake.

Lime	19·78
Magnesia	10·55
Alumina	0·75
Ferric oxide	0·27
Ferrous oxide	1·71
Manganous oxide	0·38
Carbonic anhydride	26·03
Sulphuric anhydride	0·07
Phosphoric anhydride	0·14
Silica, soluble	0·60
Water	0·20
Insoluble mineral matter	38·81
	99·29

The band from which this argillaceous magnesian limestone was taken has been supposed to be an extension of the beds affording a cement stone, which are worked by Mr. C. B. Wright, on the thirty-

fourth lot of the first concession, Ottawa front, of Nepean township. (Annual Report, vol. xi., 1900, p. 19 R.

Potsdam sandstone quarry.

A large quarry in the Potsdam sandstone on lot thirty-five of the fourth range of Nepean, from which the stone for the Parliament buildings in Ottawa was taken, has already been referred to. The quality of the stone is excellent, and in places sufficiently free from iron, to adapt it for the manufacture of glass.

Utica shale.

The black shales of the Utica formation have been found to make an excellent material for streets. The rock reduces easily to a smooth and clean surface, and has been employed on some of the streets in the eastern part of the city on Sandy Hill. It is also used for walks, as in Major Hill park, and gives excellent results.

Shell marl of Hemlock lake.

Shell marl is found in considerable quantity on the shores of Hemlock lake near Rockcliffe park. It is referred to in the Geological Survey Report for 1845-46, on page 96, and is there said to have a thickness of five feet, spreading over a breadth of 200 yards, where it becomes concealed by drift. This material is now used largely in the manufacture of hydraulic cement in western Ontario. It was formerly used for brick-making, and many of the old white brick buildings in this city are said to have been made from bricks of which this marl formed an ingredient. It has apparently not been employed for this purpose in recent years.

An analysis made in the Geological Survey laboratory (Annual Report, vol. vii., 1894, page 23, R, is as follows:—

"The air-dried material is earthy, slightly coherent; colour, yellowish-white. It contains numerous shells, also root fibres.

(After drying at 100° C.—Hygroscopic water = 0·46 per cent.)

Analysis.

Lime	52·24
Magnesia	0·13
Alumina	0·13
Ferric oxide	0·09
Potassa	traces.
Soda	traces.
Carbonic acid	41·16
Sulphuric acid	traces.
Phosphoric acid	0·02
Silica, soluble	0·11
Insoluble mineral water	1·08
Organic matter, viz., vegetable fibre in a state of decay, and products of its decay, such as humus, humic acid, etc., and possibly a little combined water	4·90
	99·86

Assuming the whole of the lime to be present in the form of carbonate, trifling quantities of which are, however, present in other forms of combination, the amount found would correspond to 93·29 per cent carbonate of lime.

The insoluble mineral matter was found to consist of :

Silica	0·72
Alumina and ferric oxide	0·24
Lime	0·04
Magnesia	0·02
Alkalies (?)	0·06
	1·08"

MINERAL WATERS.

Mineral springs.

Mineral springs are quite numerous in the vicinity of Ottawa. Among the most important may be mentioned those at Eastman, Borthwick's east of Hawthorne, and the Victoria springs, a short distance south of the Montreal road on Greens creek. They are extensively used for their medicinal properties.

BRICK CLAYS.

Brick-yards.

Brick-clays are widely developed around the city, and many important brick-yards are in operation. Two of the largest of these (Odell's and Graham's) are in Ottawa east, south of the canal. Two others are on the west bank of the canal, a short distance below the Hogs Back. Another large establishment is a short distance south of the road leading from Billings Bridge to the latter place. The brick and tile works of Mr. Wright are on a road which leads north about two miles west of the city of Hull.

Fossils.

In the clay deposits at several of these places, notably at Odell's brick-yard, marine organisms are abundant. These include shells, the bones of seals, sponges, etc., of which interesting collections have been made from time to time.

Lime kilns.

Lime kilns are numerous. They are found principally on the Montreal road, at Robillard's, and in Hull, in connection with the quarries already described.

APPENDIX

PRELIMINARY LISTS OF THE ORGANIC REMAINS OCCURRING IN THE VARIOUS GEOLOGICAL FORMATIONS COMPRISED IN THE MAP OF THE OTTAWA DISTRICT, INCLUDING FORMATIONS IN THE PROVINCES OF QUEBEC AND ONTARIO, ALONG THE OTTAWA RIVER.

BY

H. M. AMI, M.A., D. Sc., F.G.S.,
Assistant Palæontologist to the Geological Survey of Canada.

APPENDIX.

LISTS OF FOSSILS TO ACCOMPANY REPORT BY DR. R. W. ELLS ON THE CITY OF OTTAWA MAP.

By HENRY M. AMI, M.A., D.Sc., F.R.S. Can.
Assistant Palæontologist to the Geological Survey of Canada.

INTRODUCTORY.

The following lists of organic remains from various localities in the Ottawa district, are submitted as evidence obtained in the separation of the several geological formations of sedimentary origin, comprised within the area of the map accompanying the report, and also to serve as guides to collectors and students of geology and palæontology from whom numerous enquiries are constantly made to the department. These lists are by no means exhaustive, but it is confidently hoped that in the near future, more complete and systematic lists of all the species recorded or known to occur in the Ottawa district, will be published.

Excellent collections of fossils from the Ottawa District made by the late Elkanah Billings, Dr. VanCourtland, Sir James Grant, W. R. Billings, James Richardson, John Stewart, and officers of the Geological Survey department may be seen at any time in the museum of the Geological Survey on Sussex street, Ottawa.

LISTS OF FOSSILS: PLEISTOCENE.

From Green's creek, south side of Ottawa river, county of Carleton, Ont., six miles below Ottawa city, collected by Sir William Dawson and occurring in calcareous nodules from the marine clays of that locality.

1. *Potentilla Canadensis.*
2. *Drosera rotundifolia.*
3. *Acer spicatum.*
4. *Gaylussaccia resinosa.*
5. *Populus balsamifera.*
6. *Thuja occidentalis.*
7. *Potamegeton perfoliatus.*
8. " *pusillus.*
9. *Equisetum scirpoides.*

10. *Fontinalis*, sp.
11. *Fucus* or *Ulva*, sp.
12. *Carices* and *Gramineæ*, several species.

In addition to the, above, Prof. D. P. Penhallow, of the McGill College botanical laboratories, Montreal has kindly determined the following species obtained in calcareous nodules from the same locality.

1. *Acer saccharinum.*
2. *Algæ*, sp.
3. *Brasenia peltata.*
4. *Bromus ciliatus.*
5. *Cyperaceæ.*
6. *Carex Magellanica.*
7. *Equisetum limosum.*
8. " *sylvaticum.*
9. *Fucus digitatus*, N. sp.
10. *Oryzopsis asperifolia.*
11. *Populus grandidentata.*
12. *Potamogeton pectinatus.*
13. " *rutilans.*
14. *Potentilla Anserina.*

From similar nodules found in the clays at Besserer's wharf, along the Ottawa River, below the mouth of Green's creek, the following have been obtained:

1. *Betula lutea.*
2. *Cyperaceæ.*
3. *Fucus digitatus.*
4. *Hypnum fluitans.*
5. *Populus balsamifera.*
6. " *grandidentata.*
7. *Potamogeton perfoliatus.*
8. " *pusillus.*
9. " *rutilans.*
10. *Potentilla Anserina.*
11. *Vallisneria*, sp.
12. *Typha latifolia (?).*

From nodules found at Green's creek by John Stewart, 1893.

1. *Macoma fragilis*, Fabricius. (=M. Balthica, L.)
2. *Saxicava rugosa*, Linn.
3. *Leda (Portlandica) arctica*, Gray.

4. *Cylichna alba* or *C. minuta.*
5. *Balanus crenatus*, Bruguière.
6. *Mallotus villosus*, Cuvier.
7. *Cottus uncinatus*, Reinhardt.

From creek near the bridge at Cyrville, county of Carleton, Ont. Collected by John Stewart, 1893. (H. M. A. coll.)

1. *Saxicava rugosa*, Linn.
2. *Leda (Portlandia) arctica*, Gray.
3. *Balanus crenatus*, Bruguière.
4. *Mallotus villosus*, Cuvier.

From Graham's brickyard, Ottawa East. Collected by H. M. Ami.

1. *Macoma Balthica*, Linnæus.
2. *Macoma calcarea*, Chemnitz.
3. *Leda (Portlandia) arctica*, Gray.
4. *Cylichna alba*, Brown.
5. *Balanus crenatus*, Bruguière.
6. *Natica affinis*, Gmelin.

From right bank of the Rideau river, near Manotick road. Collected by R. H. Campbell, Esq., 1891-92.

1. *Macoma Balthica*, Linnæus.
2. *Saxicava rugosa*, Linn.
3. *Mytilus edulis*, Linn.
4. *Balanus porcatus*, De Costa.

From Gatineau Valley railway, half mile north of Chelsea station. Collected by W. J. Wilson, H. Nelson and H. M. A., 1894-1898.

1. *Macoma Balthica*, Linnæus.
2. *Saxicava rugosa*, Linn.
3. *Balanus crenatus*, Bruguière.
4. *Leda (Portlandica) arctica*, Gray.

From Odell's brickyard, Ottawa East. Collected by Messrs. Walter and Mortimer Odell, R. L. Burland Harold Nelson, and H. M. Ami, 1889-1896.

1. *Thuja occidentalis*, well preserved branches.
2. *Polystomella crispa*, var.

3. *Quinqueloculina seminulum.*
4. *Nonionina*, sp. cf. *N. scapha.*
5. *Polymorphina lactea.*
6. *Craniella Logani*, Dawson.
7. *Eschara elegantula*, d'Orbigny.
8. *Leda* (*Portlandia*) *arctica*, Gray.
9. *Saxicava rugosa*, Linn.
10. *Macoma Balthica*, Linn.
11. *Nucula tenuis* (Montagu).
12. *Natica affinis*, Gmelin.
13. *Velutina* (*Limneria*) *undata*, Brown.
14. *Chrysodomus despectus*, Linn.
15. *Phoca*, sp.

In addition to the above there were collected by Sir William Dawson and members of the staff of the Geological Survey, and described in Geology of Canada, 1863, pp. 916-917, from Green's creek along the Ottawa River.

1. *Cyclopterus lumpus.*
2. *Cottus*, sp.
3. *Tellina Groenlandica* (*Macoma Balthica*).
4. *Saxicava rugosa.*
5. *Drosera rotundifolia.*
6. *Trifolium repens.*
7. *Potentilla Norvegica.*
8. " *tridentata.*
9. " *Canadensis.*
10. *Arctostaphylos uva-ursi.*
11. *Populus balsamifera.*
12. *Potamogeton perfoliatus.*
13. " *natans.*
14. *Mallotus villosus.*
15. *Gasterosteus*, sp. indt.

From Wright's brickyard, north of Tétreauville, Hull, Que.

1. *Saxicava rugosa*, Linnæus.
2. *Phoca* sp. probably young of *P. vitulina.*

From Green's creek and adjacent shores of the Ottawa, in clay nodules, there were obtained by Sir William Dawson and H. M. Ami, the following remains of fossil insects described by Prof. Scudder.

1. *Tenebrio calculensis*, Scudder.
2. *Byrrhus Ottawaensis*, Scudder.

3. *Fornax ledensis*, Scudder.
4. *Phryganea ejecta*, Scudder.

The following species of Pleistocene plants are recorded by Prof. D. P. Penhallow, of McGill University, in his recent paper on "The Pleistocene Flora of the Don Valley" embodied in the Report of the committee of the British Association for the Advancement of Science appointed to report upon the "Canadian Pleistocene Fauna and Flora," published in report of the British Association for the Advancement of Science for the 1900 (Bradford meeting), pp. 328-339. Most of the forms recorded were collected by the writer and were kindly determined by Prof. Penhallow himself, who generously undertook the task of naming the species present.

From Besserer's Springs, Gloucester, Ont.

1. *Betula lutea.*
2. *Cyperaceæ.*
3. *Elodea Canadensis.*
4. *Encyonuna prostratum.*
5. *Fucus digitatus.*
6. *Hypnum fluitans.*
7. *Populus balsamifera.*
8. *Potamage ton pectinatus.*
9. " *perfsliatus.*
10. " *pusillus.*
11. " *rutilans.*
12. *Potentilla Anserina.*
13. *Typha latifolia.*
14. *Vallisneria spiralis.*

From Green's Creek, Gloucester, Ont.

1. *Acer saccharinum.*
2. *Algæ—sp.*
3. *Alnus—sp.*
4. *Brasenia peltata.*
5. *Bromus ciliatus.*
6. *Carex Magellanica.*
7. *Cyperaceæ—sp.*
8. *Drosera rotundifolia.*
9. *Elodea Camadensis.*
10. *Encyonema prostratum.*
11. *Equisetum limosum.*

12. *Equisetum scirpoides.*
13. " *sylvaticum.*
14. *Fontinalis—sp.*
15. *Fucus digitatus.*
16. *Gaylussacia,—sp.*
17. *Gramineæ resinosa.*
18. *Oryzopsis asperifolia.*
19. *Populus balsamifera.*
20. " *grandedentata.*
21. " *perfoliatus.*
22. " *pusillus.*
23. " *rutilans.*
24. *Potentilla Anserina.*
25. *Vallisneria spiralis.*

FRESH WATER DEPOSITS.

From the shell-marl deposit of Hemlock lake, New Edinburgh, the following species were obtained by H. M. Ami in 1882 :—

1. *Valvata tricarinata.*
2. *Amnicola porata.*
3. *Physa heterostropha.*
4. *Planorbis campanulatus.*
5. " *bicarinatus.*
6. " *parvus.*
7. *Limnea galbana,* Binney, an extinct species.
8. " *stagnalis.*
9. " *desidiosa.*
10. *Mesodon albolabris.*
11. " " var. *dentifera.*
12. " *Sayi.*
13. *Patula alternata.*
14. *Hyalina indentata.*
15. " *arborea.*
16. *Conulus fulvus.*
17. *Pisidium abditum.*

PALÆOZOIC ERA.

ORDOVICIAN SYSTEM.

LORRAINE FORMATION.

From a low cutting on the Canada Atlantic railway, about two and one quarter miles East of Ottawa city. Rocks : buff-weathering earthy shales and mudstones. Collected by H. M. Ami, 1884.

1. *Monticuliporoidæ*, branching forms.
2. *Orthis (Dinorthis) pectinella*, Emmons.
3. *Orthis (Dalmanella) testudinaria*, Dalman.
4. *Rafinesquina alternata*, Conrad.
5. *Strophomena Trentonensis*, Winchell and Schuchert.
6. *Leptæna (Plectambonites) sericea*, Sowerby.
7. *Zygospira Headi*, Billings.
8. *Cyrtolites ornatus*, Conrad.
9. *Bellerophon bilobatus*, Sowerby.
10. *Murchisonia subconica*, Hall or n. sp.
11. " *gracilis*, Hall.
12. *Modiolopsis modiolaris*, Conrad.
13. " *pholadiformis*, Hall.
14. *Byssonychia radiata*, Hall.
15. *Pterinea demissa*, Hall.
16. *Asaphus*, sp.
17. *Calymene senaria*, Conrad.
18. *Crinoidal* fragments.

From an outcrop on the Russell Road, township of Gloucester, lot 4, range VI., County of Carleton, Ont. Collected by R. W. Ells and N. J. Giroux, 1894.

1. *Bythotrephis*, sp.
2. *Crinoidal* fragments.
3. *Conchicolites*, sp. cf. *C. flexuosus* or possibly n. sp.
4. *Plectambonites sericea*, small form, Sowerby.
5. " " " very large oblong form.
6. *Orthis (Dalmanella) testudinaria*, Dalman.
7. " *(Dalmanella) emacerata*, Hall.
8. *Modiolopsis rhomboideus*, Hall.
9. *Clidophorus planulatus.*
10. *Byssonychia radiata*, Hall.
11. *Calymene senaria*, Conrad.

UTICA FORMATION.

From lot 17, Junction gore, near Rideau river. Collected by James Richardson, 1853.

1. *Lingula curta*, Hall,
2. " *Daphne*, Billings.
3. " *Progne*, Billings.
4. *Dalmanella testudinaria* or closely related species.
5. *Trocholites ammonius*, Emmons.
6. *Orthoceras lamellosum*, Hall.
7. *Asaphus latimarginatus*, Hall. (=*Asaphus Canadensis*, Chapman.)

From Mackay street, New Edinburgh, H. M. Ami, 1891.

1. *Intricaria* (*Subretepora*) sp. parasitic on body chamber of *Endoceras proteiforme*, Hall.
2. *Monticuliporoid (? Batostomella erratica*, Ulrich).
3. *Arthronema*, sp.
4. *Leptobolus insignis*, Hall.
5. *Dalmanella testudinaria*, Dalman.
6. *Schizocrania filosa*, Hall.
7. *Plectambonites sericea*, Sowerby.
8. *Lyrodesma pulchellum*, Emmons.
9. *Cyclonema*, sp. cf. *C. bilix*, Hall.
10. *Murchisonis*, sp.
11. *Metoptoma*, n. sp. *(Metoptoma rara, MS.)*.
12. *Trocholites ammonius*, Conrad.
13. *Conularia Trentonensis*, Hall.
14. *Endoceras proteiforme*, Hall.
15. *Orthoceras cancellatum*, Walcott.
16. *Triarthus Becki*, Green.
17. *Asaphus latimarginatus*, Hall.
18. *Calymene senaria*, Conrad.
19. *Primitia Ulrichi*, Jones.

From Cummings's Bridge, south side of Rideau river, township of Gloucester, county of Carleton, Ont. Collected by H. M. Ami, 1885.

1. *Orthograptus quadrimucronatus*, Hall.
2. *Leptograptus flaccidus*, Hall.

3. *Leptograptus annectans*, Walcott.
4. *Diplograptus truncatus*, Lapworth.
5. *Leptobolus insignis*, Hall.
6. *Schizocrania filosa*, Hall.
7. *Zygospira modesta*, Say.
8. *Pterinea Trentonensis*. Conrad.
9. " *insueta*, Conrad.
10. *Mediolopsis*, sp. indt.
11. *Orthoceras lamellosum*, Hall.
12. *Triarthus spinosus*, Billings.
13. " *Becki*, Green.

From the corner of O'Connor and Queen streets, Ottawa City. Collected by H. M. Ami, 1888.

1. *Lingula Progne*, Billings.
2. *Dalmanella testudinaria*, Dalman.
3. *Plectambonites sericea*, Sowerby.
4. *Endoceras proteiforme*, Hall.
5. *Triarthus Becki*, Green.
6. *Asaphus latimarginatus*, Hall.

From Porter's Island, Rideau River, Ottawa City, from collections made by J. C. Reichenbach, N. J. Giroux and H. M. Ami in 1894.

1. *Stephanella sancta*, Hinde.
2. *Leptograptus flaccidus*, Hall.
3. *Diplograptus amplexicaulis*, Hall or closely allied species.
4. *Leptobolus insignis*, Hall.
5. *Pterinea Trentonensis*, Conrad.
6. *Trocholites ammonius*, Emmons, very large form.
7. *Orthoceras lamellosum*, Hall.
8. *Triarthus Becki*, Green.
9. " *spinosus*, Billings.
10. Conodont (*Prionodus*), n. sp., shewing six minute rounded pointed teeth, imbedded at their base in narrow and delicate ramus. Indications of longitudinal striations faintly seen on the teeth, smaller ones appear to be intercalated between the larger ones in a couple of instances. The fragment as preserved measures 3·5 millimetres. (*Prionodus desideratus* is suggested as a designation for this species.)

From New Edinburgh, near entrance to Rideau Hall, on Mackay street. H. M. Ami, 1894.

1. *Arthronema*, sp. probably new.
2. *? Sagenella ambigua*, Walcott.
3. *Pholidops subtruncatus*, Hall, or n. sp.
4. *Lingula Progne*, Billings.
5. *Dalmanella testudinaria*, Dalman.
6. *Rafinesquina alternata*, Emmons.
7. *Plectambonites sericea*, Sowerby.
8. *Lyrodesma pulchellum*, Emmons.
9. *Modiolopsis anodontoides*, Conrad.
10. *Pleurotomaria subconica*, Hall.
11. *Conularia Trentonensis*, Hall.
12. *Trocholites ammonius*, Emmons.
13. *Orthoceras lamellosum*, Hall.
14. *Asaphus latimarginatus*, Hall.
15. *Triarthus Becki*, Green.
16. *Calymene senaria*, Conrad.
17. *Primitia*, sp.

Zone of *Schizambon Canadensis*, Ami.

From the band of impure bituminous limestone holding *Schizambon Canadensis*, at Sparks's Rapids on the east shore of the Rideau River in Gloucester, opposite the old Rideau Rifle Range—the following species of Utica fossils were obtained by the writer:—

1. *Batostomella erratica*, Ulrich.
2. *Lingula curta*, Hall.
3. " *elongata*, Hall.
4. " *quadrata*, Eichwald (cf. *Lingula Elderi*, W. & S.)
5. *Leptæna (Plectambonites) sericea*, Sowerby.
6. *Strophomena (Rafinesquina) alternata*, Conrad (Emmons).
7. *Orthis (Dalmanella) testudinaria*, Dalman.
8. *Zygospira Headi*, Billings.
9. " *modesta*, Say.
10. " sp. probably new species.
11. *Conularia Trentonensis*, Hall.
12. *Turrilepas Canadensis*, Henry Woodward.
13. *Asaphus latimarginatus*, Hall.
    (= *Asaphus Canadensis*, Chapman.)
14. *Asaphus*, sp. cf. *platycephabus*, Stokes.
15. *Calymene senaria*, Conrad.
16. *Beyrichia oculifera*, Hall or allied form.

17. *Leperditia cylindrica*, Hall.
18. *Primitia*, sp. nov.

TRENTON FORMATION.

From south shore of the Ottawa, Nepean point, between Parliament hill and the steamboat landing. H. M. Ami.

1. *Palæophycus obscurus*, Billings.
2. *Licrophycus gracilis*, Hall.
3. *Stenaster Salteri*, Billings.
4. *Agelacrinites Chapmani*, Billings.
5. *Glyptocrinus ramulosus*, Billings.
6. *Rhodocrinus (Archæocrinus) pyriformis*, Billings.
7. *Prasopora lycoperdon*, Vanuxem. (=*P. Selwyni*, Nich.)
8. *Monotrypella Trentonensis*, Nicholson.
9. *Protarea vetusta*, Hall.
10. *Streptelasma corniculum*, Hall.
11. *Diplograptus*, sp.
12. *Rafinesquina alternata*, Conrad (Emmons).
13. " *deltoidea*, Conrad.
14. *Strophomena incurvata*, Shepard.
15. *Dalmanella testudinaria*, Dalman.
16. *Hebertella insculpta*, Hall.
17. *Plectambonites sericea*, Sowerby.
18. *Platy-trophia biforata*, Schlotheim, var. lynx, Eichwald.
19. *Trochonema umbilicatum*, Hall.
20 *Murchisonia (Hormotoma) bellicincta*, Hall.
21. " " *gracilis*, Hall.
22. *Raphistoma lenticulare*, Hall.
23. *Ambonychia amygdalina*, Billings.
24. *Calymene senaria*, Conrad.
25. *Asaphus platycephalus*, Stokes.

From Nepean point, collected by R. H. Campbell, H. D. Herdt and H. M. Ami, 1890.

1. *Licrophycus*, sp.
2. *Bythrotrephis succulens*, Billings.
3. *Rhodocrinus (Archæocrinus) pyriformis*, Billings.
4. *Prasopora lycoperdon*, Vanuxem,
5. *Pachydictya acuta*, Hall.
6. *Dalmanella testudinaria*, Dalman.

7. *Rafinesquina alternata*, Conrad (Emmons).
8. *Plectambonites sericea*, Sowerby.
9. *Platystrophia biforata*, var. lynx, Eichwald.
10. *Zygospira recurvirostra*, Hall.
11. *Bellerophon bilobatus*, Sowerby.
12. *Pleurotomaria Daphne*, Billings.

From Brigham's quarry, Hull. Collected by H. M. Ami and T. M. Hardie, 1883.

1. *Periglyptocrinus Billingsi*, W. & S.
2. *Glyptocrinus ramulosus*, Billings,
3. *Archæocrinus pyriformis*, Billings.
4. *Dendrocrinus congregatus*, Billings.
5. " *acutidactylus*, Billings.
6. *Solenopora compacta*, Billings.
7. *Ptilodictya falciformis*, Nicholson.
8. *Rhinidictya paupera*, Nicholson.
9. *Graptodictya*, sp.
10. *Arthroclema pulchellum*, Billings.
11. *Prasopora lycoperdon*, Vanuxem.
12. *Monotrypella Trentonensis*, Nicholson.
13. *Batostoma Ottawaënse*, Foord.
14. *Pachydictya acuta*, Hall.
15. *Monticulipora Billingsi*, Foord.
16. *Spatiopora areolata*, Foord
17. *Ptilodictya maculata*, Ulrich.
18. *Lingula Philomela*, Billings.
19. " *elongata*, Hall,
20. *Dalmanella testudinaria*, Dalman.
21. *Rafinesquina alternata*, Conrad (Emmons).
22. *Plectambonites sericea*, Sowerby.
33. *Skenidium Merope*, Billings.
24. *Rhynchonella (Rhynchotrema) inæquivalvis*, Castelnau.
25. *Serpulites dissolutus*, Billings.
26. *Murchisonia (Hormotoma) gracilis*, Hall.
27. *Asaphus platycephalus*, Stokes.
28. *Calymeme senaria*, Conrad.

From Hull quarries. Collected by John Stewart, 1885-93.

1. *Archæocrinus microbasalus*, Billings,
2. *Dendrocrinus acutidactylus*, Billings.
3. *Dendrocrinus conjugans*, Billings.

4. *Glyptocrinus*, sp.
5. *Periglyptocrinus Billingsi*, Wach. & Spr.
6. *Archæocrinus desideratus*, W. R. Billings.
7. " *pyriformis*, Billings.
8. *Cleiocrinus grandis*, Billings.

From Beaver meadow, Hull. H. M. Ami, 1891.

1. *Pachydictya acuta*, Hall.
2. *Prasopora lycoperdon*, Vanuxem.
3. *Dalmanella testudinaria*, Dalman.
4. *Rafinesquina alternata*, Conrad.
5. *Plectambonites sericea*, Sowerby.
6. *Platystrophia biforata*, Schlotheim, v. lynx, Eichwald.
7. *Conularia Trentonensis*, Hall.
8. *Bellerophon bilobatus*, Sowerby.
9. *Zygospira recurvirostra*, Hall.
10. *Orthis (Hebertella) occidentalis*, Hall.
11. *Asaphus platycephalus*, Stokes.
12. *Calymene senaria*, Cunrad.
13. *Dalmanites Bebryx*, Billings.

From Majors Hill Park, near rustic house overlooking cliff facing the Chaudière falls. H. M. A., 1890.

1. *Streptelasma corniculum*, Hall.
2. *Amplexopora discoidea*, James.
3. *Dalmanella testudinaria*, Dalman.
4. *Plectorthis plicatella*, Hall.
5. *Platystrophia biforata*, v. lynx, Eichwald.
6. *Rafinesquina alternata*, Conrad.
7. " *deltoidea*, Conrad.
8. *Plectambonites sericea*, Sowerby.
9. *Murchisonia (Hormotoma) bellicincta*, Hall.
10. *Trochonema umbilicatum*, Hall.
11. *Illœnus Americanus*, Billings.

From quarry near Rockcliffe, New Edinburgh. H. M. Ami.

1. *Solenopora compacta*, Billings.
2. *Prasopora Selwyni*, Nicholson.
3. *Rafinesquina alternata*, Conrad (Emmons).
4. *Strophomena incurvata*, Shepard.

From Wright's new quarries, Hull, H. M. Ami, 1889.

1. *Brachiospongia digitata*, Owen.
2. *Solenopora compacta*, Billings.
3. *Arthroclema pulchellum*, Billings.
4. *Monticulipora ? mammillata*, d'Orbigny.
5. *Prasopora lycoperdon*, Nicholson.
6. *Asteroporites Ottawaënsis*, Lambe.
7. *Pachydictya acuta*, Hall.
8. *Amplexopora* or *Batostoma*, sp.
9. *Glyptocrinus* stems.
10. *Lingula*, sp.
11. *Trematis Ottawaënsis*, Billings.
12. *Dalmanella testudinaria*, Dalman.
13. *Orthis*, sp. indt.
14. *Rafinesquina alternata*, Conrad, (Emmons).
15. *Zygospira*, sp., cf. *Z. recurvirostra*, Hall.
16. *Conularia*, sp. probably n. sp.
17. *Cyclonema bilix*, Hall.
18. *Lichas Trentonensis*, Hall.
19. " sp. indt.
20. *Asaphus platycephalus*, Stokes.
21. *Illaenus Trentonensis*, Billings.
22. " sp. with very narrow *pygidium.*

From Sussex street, below Hamilton Brothers' office.

1. *Heterocrinus simplex*, Hall, var. *Canadensis*, Billings.
2. *Zygospira recurvirostra*, Hall very abundant.

From shore of Ottawa river at Queen's or steamboat wharf, Ottawa city. H. M. Ami, 1884.

1. *Bythotrephis flexuosus*, Emmons, or *B. succulens*, Billings.
2. *Pasceolus globosus*, Billings.
3. *Pachydictya acuta*, Hall.
4. *Monticuliporidæ*, several species.
5. *Plectambonites sericea*, Sowerby.
6. *Rafinesquina alternata*, Conrad (Emmons).
7. *Strophonema incurvata*, Shepard.
8. *Orthis (Dalmanella) testudinaria*, Dalman.
9. " " *occidentalis, Hall.*
10. *Rhynchotrema inæquivalvis*, Castelnau.
11. *Asaphus platycephalus*, Stokes.
12. *Proëtus parviusculus*, Hall.

From Rideau Hall grounds, New Edinburgh. Collected by T. M. Hardie and H. M. A., 1883..

1. *Streptelasma corniculum*, Hall.
2. *Solenopora compacta*, Billings.
3. *Lichenocrinus crateriformis.* Hall.
4. *Iocrinus subcrassus*, Meek and Worthen.
5. *Serpulites dissolutus*, Billings.
6. (?) *Amplexopora Canadensis*, Foord.
7. *Monticuliporidæ* not described.
8. *Discina Circe*, Billings *(Orbiculoidea lamellosa)*, Hall.
9. *Dalmanella testudinaria*, Dalman.
10. *Orthis (Skenidium) Merope*, Billings.
11. *Platystrophia biforata*, Schlotheim.
12. *Rafinesquina alternata* Conrad (Emmons).
13. *Plectambonites sericea*, Sowerby.
14. *Rhynchotrema inæquivalvis*, Castelnau.
15. *Zygospira recurvirostra*, Hall.
16. *Trochonema umbilicatum*, Hall.
17. *Murchisonia (Hormotoma) bellicincta*, Hall.
18. " *gracilis* Hall.
19. " *perangulata*, Hall.
20. *Asaphus platycephalus*, Stokes.
21. *Calymene senaria*, Conrad.

From Rideau Hall grounds, additional. Collected by Lords Kerry and Charles, and Mr. A. J. Galpin of Government House, 1885.

1. *Cystidean* plates, sp. indt.
2. *Crinoidal* fragments.
3. *Pachydictya acuta*, Hall.
4. *Amplexopora discoidea*, James.
5. *Solenopora compacta*, Rillings.
6. *Prasopora lycoperdon*, Vanuxem
7. " *oculata*, Foord.
8. *Orthis (Plectorthis) Laurentina*, Billings.
9. " (*Hebertella*) *occidentalis*, Hall.
10. " (*Dinorthis*) *pectinella*, Emmons.
11. *Strophomena incurvata*, Shepard.
12. *Murchisonia Milleri*, Hall.
13. *Pleurotomaria subconica*, Hall.
14. *Fusispira subfusiformis*, Hall.
15. *Endoceras proteiforme*, Hall.
16. *Gonioceras anceps*, Hall. (locality doubtful, H.M.A.)

17. *Asaphus megistos, (?)* Locke.
18. *Ceraurus*, sp.
19. *Illaenus*, sp.

From Governor General's bay. Collectors, H. M. Ami and Prof. J. Fowler, 1889.

1. *Amplexopera Canadensis (?)* Foord.
2. *Prasopora lycoperdon*, Vanuxem (*P. Selwyni*) Nicholson.
3. *Pachydictya acuta*, Hall.
4. *Homotrypa (?)* sp. indt.
5. *Amplexopora discoidea*, James.
6. *Solenopora compacta*, Billings.
7. *Arthronema*, sp.
8. *Rhinidictya paupera*, Nicholson.
9. *? Helopora*, sp.
10. *Batostoma Ottawaënsis*, Foord.
11. *Monotrypella Trentonensis*, Nicholson.
12. *Parastrophia hemiplicata*, Hall.
13. *Pholidops subtruncatus*, Hall.
14. *Trematis*, sp.
15. *Rafinesquina alternata*, Conrad (Emmons).
16. *Dalmanella testudinaria*, Dalman.
17. *Plectambonites sericea*, Sowerby.
18. *Orthis plicatella*, Hall.
19. *Anastrophia*, sp.
20. *Zygospira recurvirostra*, Hall.
21. *Orthis (Hebertella) insculpta*, Hall.
22. *Platystrophia biforata*, var. lynx Eichwald.
23. *Murchisonia (Hormotoma) gracilis*, Hall.
24. " " *bellicincta*, Hall.
25. *Remopleurides affinis*, Billings, or allied species.
26. *Encrinurus vigilans*, Hall.
27. *Calymene senaria*, Conrad.
28. *Asaphus platycephalus*, Stokes.
29. *Lichas Trentonensis*, Hall.
30. *Ceraurus pleurexanthemus*, Green.
31. *Dalmanites callicephalus*, Green.
32. *Beyrichia*, sp.

The shaly and calcareous strata of the Trenton of Governor's Bay, New Edinburgh, Ottawa, and of the first cutting on the Pontiac and Pacific Railway west of the C. P. R. crossing at Hull on the way

to Aylmer, belong to one and the same geological horizon. The following table of the occurrence of species from "The Heap" at Hull, (which material was derived from the above mentioned cutting) and from the Trenton of Governor's Bay, will serve to indicate the association of species at both localities.

List of Fossils from the Trenton of Governor's Bay, Ottawa, Ontario, and from "The Heap," Hull, Quebec.

rr—rather rare; r—rare; c—common; rc—rather common; a—abundant.

Genera and Species.	Author.	Governor's Bay, Ottawa	"The Heap," Hull, Que.	Prevalence.
Hetcrocrinus simplex	Billings		*	rr
Crinoidal fragments		*	*	c
Amplexopora discoidea	James	*		rc
Prasopora Selwyni	Nicholson	*	*	a
Monotrypella Trentonensis	"	*	*	rc
Pachydictya acuta	Hall		*	rc
Stylodictya, n. sp			*	r
Pachydictya, sp			*	r
Pholidops subtruncatus	Hall	*	*	rc
Plectambonites sericea	Sowerby	*	*	a
Rafinesquina alternata	Conrad	*		a
Strophomena incurvata	Shepard	*	*	ra
Dalmanella testudinaria	Dalman	*	*	a
Dinorthis pectinella	Emmons		*	rc
Plectorthis, sp. cf., *P. Whitfieldi*	Winchell	*		rc
Hebertella occidentalis	Hall	*	*	rr
Platystrophia biforata	Schlotheim	*	*	rc
Rhynchotrema inæquivalvis	Castelnau	*	*	c
Parastrophia hemiplicata	Hall	*	*	c
Cyclospira bisulcata	Emmons		*	rr
Zygospira recurvirostra	Hall	*	*	a
Tetranota, sp		*		r
Bellerophon bilobatus	Sowerby	*	*	c
Conularia Trentonensis	Hall	*		rr
Trochonema umbilicatum	"	*	*	rc
Hormotoma gracilis	"		*	r
Lophospira perangulata	"		*	r
Whitella, sp. indt			*	r
" *subcarinata?*	Billings	*		r
Plcurotomaria, sp		*		r
Orthoceras, sp		*		r
Turrilepas Ottawaënsis (nobis)		*		r
Calymene senaria	Conrad	*	*	rc
Remopleurides affinis, var	Billings	*		r
Ceraurus pleurexanthemus	Green		*	r
Pterygometopus callicephalus	Hall	*		rc
" sp			*	r
" *intermedius*	Walcott	*		r
Asaphus platycephalus	Stokes	*	*	rc
Beyrichia, n. sp		*		rr
Isochilina, n. sp		*		rr

From foot of cliff, Ottawa river, between Queen's wharf and Nepean point. H. M. Ami, 1899.

1. *Bythotrephis succulens*, Hall.
2. *Bythotrephis*, n. sp.
3. *Crinoidal* columns, not determined.
4. *Prasopora lycoperdon*, (*P. Selwyni*, Nicholson).
5. *Plectambonites sericea*, Sowerby.
6. *Rafinesquina alternata*, Conrad. (Emmons.)
7. *Orthis* (*Dalmanella*) *testudinaria*, Dalman.
8. *Rhynchotrema inæquivalvis*, Castelnau.
9. *Zygospira recurvirostra*, Hall.
10. *Orthis* (*Dinorthis*) *plicatella*, Hall.
11. *Rafinesquina deltoidea*, Conrad.
12. *Strophomena incurvata*, Shepard.
13. *Murchisonia* (*Hormotoma*) *Augustina*, var. *Ottawaënsis*. n. var.
14. *Trochonema umbilicatum*, Hall.
15. *Calymene senaria*, Conrad.
16. *Encrinurus*, sp.
17. *Pterygometopus callicephalus*, Green.
18. *Asaphus*, sp. indt.

From vacant lot, corner Rideau and Sussex streets. H. M. Ami, 1894.

1. *Crinoidal* fragments.
2. *Leptæna* (*Plectambonites*) *sericea*, Sowerby.
3. *Strophomena* (*Rafinesquina*) *alternata*, Conrad. (Emmons).
4. *Murchisonia* (*Hormotoma*) *gracilis*, Hall.
5. " " *bellicincta*, Hall.

From Brigham's creek, back of Hull. R. W. Ells and N. J. Giroux, 1894.

1. *Crinoidal* fragments.
2. *Pachydictya*, sp.
3. *Monticuliporoidea.*
4. *Straphomena incurvata*, Shepard.
5. *Rafinesquina alternata*, Conrad. (Emmons.)
6. *Parastrophia hemiplicata*, Hall.
7. *Cyrtodonta Canadensis?* Billings.
8. *Asaphus*, sp.
9. *Dalmanites callicephalus*, Green.
10. *Bathyurus extans*, Hall.
11. *Illœnus*, sp.
12. *Murchisonia Milleri*, Hall.

TRENTON AND BLACK RIVER.

From lots 22-23, ranges II-III Nepean, near Fallowfield, Ont. Collected by R. W. Ells and N. J. Giroux, 1894.

1. *Tetradium fibratum*, Safford.
2. *Pachydictya*, sp.
3. *Glyptocrinus* stems.
4. *Orthis*, sp.
5. *Skenidium Merope*, Billings.
6. *Dalmanella testudinaria*, Dalman.
7. *Rhynchonella*, sp.
8. *Orthis* (*Plectorthis*) *plicatella*, Hall.
9. " *tricenaria*, Conrad.
10. *Rafinesquina alternata*, Conrad.
11. *Strophomena incurvata*, Shepard.
12. *Murchisonia* (*Hormotoma*) *gracilis*, Hall.
13. *Cyclonema*, sp.
14. *Murchisonia* (*Hormotoma*) *gracilis*, Hall.
15. *Asaphus*, sp. (*A. platycephalus*), Stokes.

THE BLACK RIVER FORMATION.

From Keefer's bluff, near the entrance to Beechwood Cemetery, township of Gloucester. H. M. Ami.

1. *Tetradium fibratum*, Safford.
2. *Columnaria Halli*, Nicholson.
3. *Orthis tricenaria*, Conrad.
4. *Cyrtodonta*, sp. cf. *C. Huronensis*, Billings.
5. *Murchisonia* (*Hormotoma*) *gracilis*, Hall.
6. *Trochonema umbilicatum*, Hall.
7. *Helicotoma planulata*, Salter.
8. *Actinoceras Bigsbyi*, Stokes.
9. *Asaphus*, sp. indt.
10. *Bathyurus*, cf. *B. extans*, Hall.
11. *Isochilina*, sp.
12. *Ostracoda* (*Leperditia* and *Beyrichia*) several forms.

From the western portions of lots 3-4, range III, River front, Gloucester, Carleton county. W. R. Billings, 1884. Listed in the Transactions of the Ottawa Field-Naturalists' Club, vol. II, No. 6, pp. 259-260; 1884, by Walter R. Billings, Esq.

1. *Stromatocerium rugosum*, Hall.
2. *Tetradium fibratum*, Safford.

3. *Pachydictya acuta*, Hall.
4. *Orthis tricenaria*, Conrad.
5. *Rhynchotrema inæquivalvis*, Castelnau.
6. *Strophonema Trentonensis*, Winchell & Schuchert.
7. *Bucania expansa*, Hall.
8. " *punctifrons*, Emmons.
9. " *bidorsata*, Hall.
10. *Ophileta Ottawaënsis*, Billings.
11. *Ecculiomphalus Trentonensis*, Hall.
12. *Helicotoma planulata*, Salter.
13. *Raphistoma Progne*, Billings.
14. *Pleurotomaria subconica*, Hall.
15. *Subulites* (*Fusispira*) *subfusiformis*, Hall.
16. " " *elongata*, Hall.
17. *Cyclonema Hallianum*, Salter.
18. *Murchisonia Milleri*, Hall.
19. " " var. *perangulata*, Hall.
20. " (*Lophospira*) *helicteres*, Salter.
21. *Endoceras annulatum*, Hall.
22. *Orthoceras bilineatum*, Hall.
23. " *multicameratum*, Hall.
24. " *amplicameratum*, Hall.
25. *Lituites convolans* (=*L. Americanus*, d'Orbigny).
26. *Cyrtodonta Canadensis*, Billings.
27. " *obtusa*, Bilings.
28. " *Huronensis*, Billings.
29. " *subtruncata*, Hall.
30. " *subcarinata*, Billings.
31. *Ambonychia orbicularis*, Emmons.
32. *Modiolopsis Trentonensis*, Hall.
33. " *modiolaris*, Conrad.
34. " *Meyeri*, Billings.
35. " *Gesneri*, Billings.
36. *Illaenus ovatus*, Billings.
37. " *Milleri*, Hall.
38. *Bathyurus extans*, Hall.
39. *Ceraurus pleurexanthemus*, Green.

From the ridge north of Aylmer, Hull township, Quebec. Collected by T. W. E. Sowter, 1883.

1. *Bythotrephis* (*Chondrites*), sp.
2. *Stromatocerium rugosum*, Hall.

3. *Tetradium fibratum*, Safford.
4. *Solenopora compacta*, Billings.
5. *Amplexopora discoidea*, James.
6. *Pachyd·ctya acuta*, Hall.
7. *Ptilodictya maculata*, Ulrich.
8. *Rafinesquina alternata*, Conrad, (Emmons).
9. *Strophonema incurvata*, Shepard.
10. *Plectambonites sericea*, Sowerby.
11. *Zygospira recurvirostra*, Hall.
12. *Murchisonia perangulata*, Hall.
13. *Cyrtodonta Huronensis (?)* Billings.
14. *Cyrtoceras anceps*, Hall.
15. *Actinoceras Bigsbyi*, Stokes.
16. *Endoceras multitubulatum ?* Hall.
17. *Gonioceras anceps*, Hall.
18. *Asaphus platycephalus*, Stokes.
19. *Isochilina*, sp.

From Little Chaudière, Ottawa river, Mechanicsville. Collector, E. Billings.

1. *Calapœcia Canadensis*, Billings.
2. *Streptelasma corniculum*, Hall.
3. *Rhynchotrema inœquivalvis*, Castelnau.
4. *Strophomena incurvata*, Shephard.
5. *Cyrtodonta subtruncata*, Hall sp.
6. *Pleurotomaria subconica*, Hall.
7. *Actinoceras Bigsbyi*, Stokes,
8. *Orthoceras bilineatum*, Hall.
9. " *decrescens*, Billings.
10. *Oncoceras constrictum*, Hall.
11. *Cyrtoceras*, sp. large form, indt.
12. " *sinuatum*, Billings.
13. *Gonioceras anceps*, Hall.
14. *Cyroceras vagrans*, Billings
15. *Illœnus Trentonensis*, Billings.
16 " *ovatus*, Billings.
17 " *Conradi*, Billings.

From Hog's Back, Rideau river, south side, R. W. Ells and N. J, Giroux, 1894.

1. *Crinoidal* columns.
2. *Glyptocrinus*, large stems, cf, G. *priscus*, Billings.

3. *Monticuliporidae*, branching forms, cf. Batostoma &c.
4. *Strophonema*, sp. indt.
5. *Rhynchotrema inœquivalvis*, Castelnau.
6. *Vanuxemia Montrealensis*, Billings.
7. *Cyrtodonta Huronensis*, Billings.
8. *Pleurotomaria subconica*, (?) Hall.
9. *Cyrtoceras*, sp.
10. *Strophomena incurvata*, Shepard.
11. *Bellerophon bilobatus*, Sowerby.
12. *Dalmanites*, sp.
13. *Illœnus globosus ?* Billings.
14. " *Bayfieldi*, Billings.
15. *Asaphus*, sp.
16. " cf. A. *platycephalus*, Stokes.
17. *Ceraurus pleurexanthemus*, Green.

From lots 24-28, range V, Nepean, R. W. Ells and N. G. Giroux, 1894.

1. (?) *Phytopsis tubulosum*, Hall. (Probably a *Bythotrephis*).
2. *Solenopora compacta*, Billings.
3. *Tetradium fibratum*, Safford.
4. *Monticuliporidae*, branching forms.
5. *Streptelasma*, sp.
6. *Helicotoma*, sp.
7. *Trochonema umbilicatum*, Hall.
8. " *pauperum*, Hall.
9. *Murchisonia* (*Hormotoma*) *gracilis*, Hall.
10. " *perangulata*, Hall.

From bluff, one quarter of a mile south of City View post-office, township of Nepean, collected by H. M. Ami and R. W. Ells 1899.

1. *Bythotrephis*, sp.
2. *Phytopsis tubulosum*, Hall.
3. *Stromatocerium rugosum*, Hall.
4. *Tetradium fibratum*, Safford.
5. *Columnaria Halli*, Nicholson.
6. *Streptelasma profundum*, Hall.
7. *Crinoid stems.*
8. *Monticuliporidae*, two species.
9. *Orthis tricenaria*, Conrad.
10. *Dalmanella testudinaria*, Dalman.

11. *Rafinesquina alternata*, Conrad, (Emmons).
12. *Strophonema incurvata*, Shepard.
13. *Rhynchotrema inœquivalvis*, Castelnau.
14. *Ctenodonta nasuta*, Hall.
15. *Trochonema umbilicatum*, Hall.
16. *Murchisonia, cf. M. perangulata*, Hall.
17. *Maclurea*, sp, indt.
18. *Orthoceras (Actinoceras) Bigsbyi*, Stokes.
19. " *annellum*, Hall.
20. *Cyrtoceras*, sp. indt.
21. *Gonioceras anceps*, Hall.
22. *Asaphus*, sp. large form.

From a low escarpment near City View corner, on Mr. J. R. Booth's property County of Carleton, Ont.

1. *Phytopsis*, large radiating form.
2. *Monticuliporidae*, several forms.
3. *Strophomena incurvata*, Shepard.
4. *Rafinesquina alternata*, Emmons, Conrad.
5. *Dalmanites testudinaria*, Dalman.
6. *Rhynchotrema inœquivalvis*, Castelnau.
7. *Trochonema umbilicatum*, Hall
8. *Subulites (Fusispira) Canadensis*, Ulrich.
9. *Actinoceras Bigsbyi*, Stokes.
10. *Asaphus*, very large form.

THE CHAZY FORMATION.

From north side of Ottawa river, shore at Deschênes Mills. Collected by H. M. Ami, 1884.

1. *Rhynchonella orientalis*, Billings.
2. *Monticuliporidæ*, sp. indt.
3. *Orthis (Hebertella) imperator, (?)*, Billings.
4. *Orthis (Hebertella) borealis*, Billings.
5. *Pleurotomaria*, sp. or *Raphistoma*, sp.

From Aylmer, Que., collected by T. W. E. Sowter, 1885.

1. *Rhynchonella*, sp., cf. *Rhynchonella (Camarotœchia) plena*, Hall.
2. " *orientalis*, Billings.
3. *Orthis (Hebertella) borealis*, Billings.

From Hog's Back, Rideau river, township of Nepean, H. M. Ami, 1890.

1. *Columnaria incerta*, (*?*), Billings.
2. *Lingula Belli*, Billings.
3. " cf. *L. Mantelli*, Billings.
4. *Pleurotomaria* (*Scalites*) *calyx*, Billings.
5. " (*?*) sp. indt.
6. *Cyrtodonta*, sp. cf. *C. breviuscula*, Billings.
7. *Bathyurus Angelini*, Billings.
8. *Isochilina Ottawa*, Jones.
9. *Ostracoda*. Several forms sent to Prof. T. Rupert Jones for identification.

From lot 8, range IV, Hull township, in a brook near Wright's brickyard, R. W. Ells and N. J. Giroux.

1. *Cyrtodonta*, sp., probably a new species.

Hog's Back, Nepean Township, County of Carleton, Ont. From collections made by Dr. Whiteaves, Dr. Ells, Messrs. Giroux Herdt, McConnell, McInnes, Lambe, Moore, Wait and H. M. A

Plantæ.

1. *Palæophycus ?* sp., probably an undescribed form.

Brachiopoda.

2. *Lingula Belli*, Billings.
3. " *Huroneusis*, Billings.
4. " *Mantelli*, Billings, or a very closely related species.
5. *Rhynchonella* (*Camarotœchia*) *plena*, Hall.

Vermes.

6. *Serpulites*, n. sp. A form distinct from *Serpulites splendens*, Billings, and *S. dissolutus*, Billings. Probably an undescribed species.

Pelecypoda.

7. *Ctenodonta breviuscula*, Billings.
8. *Ctenodonta*, sp.
9. *Modiolopsis parviuscula*, Billings.

Gasteropoda.

10. *Pleurotomaria* (*Scalites*) *calyx*, Billings.
11. *Trochonema pauperum*, Hall (sp.).
12. *Murchisonia*, sp., indt.
13. *Cyclonema*, sp.

Cephalopoda.

14. *Orthoceras*, sp. cf., *Orthoceras Allumettense*, Billings.
15. *Orthoceras*, sp., a form with rather distant septa and gradually tapering shell.

Trilobita.

16. *Bathyurus*, sp., cf., *Bathyurus caudatus*, Billings.
17. *Bathyurus*, sp. cf., *Bathyurus Angelini*, Billings.
18. *Asaphus canalis*, Conrad.
19. *?Bolbocephalus*, sp.

Ostracoda.

20. *Isochilina Amiana*, Ulrich (=*Isochilina Ottawa*, var. intermedia, Jones.)
21. *Primitia*, sp.

Burrows or Tracks and trails of organisms.

22. *Scolithus prolificus*, MS.
23. *Protichnites* (?) *sparcus*, MS.

THE CALCIFEROUS FORMATION.

On lot 19, Con. VIII, of the township of Marlborough, in the County of Carleton, Ont., the following species of characteristic fossils were obtained in 1899 by Dr. R. W. Ells and the writer, and determined by the latter :—

1. *Ophileta complanata*, Vanuxem. (= *Ophileta compacta*, Salter).
2. *Ophileta disjuncta*, Billings.
3. *Pleurotomaria Canadensis*, Billings.
4. " *calcifera*, Billings.
5. *Orthoceras Lamarcki*, Billings.
6. *Ribeiria calcifera*, Billings.

From the magnesian and semicrystalline limestones of the Black Rapids, nine miles above Ottawa City, on the Rideau River, *Ophileta complanata*, Vanuxem was obtained by the writer in 1881. Its presence is sufficient to predicate the occurrence of strata belonging to the Calciferous formation.

THE POTSDAM FORMATION.

From the nearest outcrops of the Potsdam formation to Ottawa City, no organic remains have as yet been detected. Footprints, or tracks and trails, of marine organisms have however been recorded by Sir William Logan and Sir Richard Owen from the eastern and western extension of the same geological horizon about Ottawa.

1. *Perth, Ont.*—In the vicinity of Perth, the late Dr. Wilson discovered tracks of organisms in the sandstones of this formation, which were subsequently described under the name of *Climactichnites Wilsoni*, by Sir William Logan himself. A large slab from the Perth quarries, illustrating the type of this species is now on exhibition in the palæontological division of the National Museum.

2. *Beverley and South Crosby, Ont.*—At Beverley and in South Crosby outcrops of a sandstone referred to the Potsdam formation by Sir Wm. Logan are known to yield abundance of the following species.

1. *Palæophycus Beverleyensis*, Billings.
2. *Lingulepis acuminata*, Conrad.
3. *Scolithus Canadensis*, Billings.

3. *Nepean or Bishop's Quarries.*—Although these quarries from which the bulk of the material with which the Parliament Buildings were constructed, were examined carefully for organic remains, none have as yet been detected. From the relative position of these sandstones, to the magnesian limestones of the Calciferous adjoining, there is no doubt that they belong to the Potsdam formation.

4. *Buckingham, Que.*—From the bluff at the foot of the falls and rapids below the bridge along the line of the Canadian Pacific Railway, west of Buckingham Station and Basin specimens of *Scolithus Canadensis*, Billings, were found by the writer in a band about eighteen feet above low water mark on the Du Lièvre River.

5. *Rockland, Ont.*—No organic remains were obtained from the outcrops of the Potsdam formation at the Rockland Mills, nor near the residence of Mr. W. C. Edwards, M.P.

6. *Monte Bello, Que.*—Between Papineauville, and the "Manoir de Monte Bello" and on the Presqu'Ile and Squirrel Island interesting outcrops of the Potsdam sandstone occur with many of their surfaces showing ripple-marks and other phenomena of wind and wave action, besides several tracks and trails of marine organisms similar to those described by Sir Richard Owen from the Potsdam of Beauharnois on the St. Lawrence, were observed by Sir William Dawson and the writer during field-days of the Natural History Society of Montreal and the Ottawa Field-Naturalists' Club. These include at least two species, viz. :—

1. *Protichnites septem-notatus*, Owen.
2. *Protichnites lineatus*, Owen.

GEOLOGICAL SURVEY OF CANADA
ROBERT BELL, M.D., D.Sc., LL.D., F.R.S., DIRECTOR.

SECTION OF MINES AND MINERAL STATISTICS.

REPORT

ON THE

IRON ORE DEPOSITS

ALONG THE

KINGSTON AND PEMBROKE RAILWAY

IN

EASTERN ONTARIO

BY

ELFRIC DREW INGALL, M.E.

Associate of the Royal School of Mines, England, Mining Engineer to the Geological Survey of Canada.

OTTAWA
PRINTED BY S. E. DAWSON, PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1901

No 723

Geological Survey of Canada,
Ottawa.

Robert Bell, M.D., D.Sc., LL.D., F.R.S.,
Deputy Head and Director.

Sir:—Herewith I beg to hand you my report on the iron ore deposits of that portion of eastern Ontario tributary to Kingston, covering part of the counties of Frontenac, Lanark, Renfrew and Leeds. It comprises the detailed results of field-work done in 1895 and 1900, supplementing a previous condensed report on the subject. In this work I was assisted by Mr. A. M. Campbell, in 1895, and Mr. T. Denis, B.A., Sc., in 1900.

The general map accompanying the report, is the work of Mr. James White, F.R.G.S., during previous years, when he was attached to the staff of the Mines Section. It was originally undertaken with a view to illustrating the location of the many scattered deposits of phosphate, mica, etc., in that district, and is now issued as an adjunct to this report to provide a means of showing the location of those deposits examined in the course of our work, and also of others gathered from reliable outside sources.

Thanks are due for assistance received, to the officials of the Kingston and Pembroke Railway Company, also to Senator McLaren, Messrs. Joseph Bawden, Wm. Caldwell, J. G. Campbell, R. J. Drummond, W. C. Caldwell, T. B. Caldwell, M. Grady, S. Jackson, T. W. Schwendiman, J. Donnelly, A. J. Macdonell, and many others.

I am, sir,
Your obedient servant,

ELFRIC DREW INGALL.

Mines Section,
24th June, 1901.

PART I.—INTRODUCTION.

Scope and character of the investigations made.

In view of the proposed inauguration of iron smelting at Kingston, Ontario, in 1895, an investigation was undertaken in that year in order to ascertain the capabilities of the district tributary to the Kingston and Pembroke railway, for the supply of ore. The field-work occupied about eleven weeks, and a summarized report of the results was issued shortly afterwards in the Annual Summary Report of the Director of the Geological Survey. This included all information having an immediate and practical bearing on the ore supply question, but the working out in detail of the data collected and the preparation of the same for publication was delayed, owing to the intervention of other work. During the summer of 1900, this investigation was further prosecuted in the field so as to bring our information up to date. The more prominent mines were further examined and more complete magnetic surveys were made with the dial compass as well as the dip needle. This necessarily resulted in the acquirement of much more information. and a better understanding of the problems involved. The substance of the 1896 report is here reproduced, forming as it does, a fitting introduction to the details given in the second part of the present report.

The main points upon which information was asked by the Kingston people in 1895, and which were covered by the report issued in 1896, already referred to, were as follows :—

The quantity of available ore from immediately accessible localities ?

The quality of the same ?

The first question, for its solution requires a correct understanding of the nature of the deposits of the district, and therefore of their reliability as to continuity in length, depth, and thickness. This is particularly the case owing to there being no mines then working (1896) from which to judge of the behaviour of the deposits in depth. At a number of places extensive openings have been made, but work had been discontinued throughout the district for several years, and the excavations being filled with water, nothing but the surface features remained available for the study of the question.*

* The results of the studies of the mines working during 1900 are given later in the report.

It is thus evident that, using the term "ore in sight" in its proper sense, at none of the places visited were the conditions such as to allow of measurements being made of the cubic contents, and therefore of the tonnage of any considerable block of ore, unless one assumed or imagined, at least one of the three dimensions necessary to be ascertained. At some places there was found a stock pile of ore selected from the material mined; but, apart from that, the question of available ore becomes one of judging, in a general way, the possibilities of the supply from deposits already discovered and worked, and of the probability of discovering yet other deposits throughout the district in the future.

Places visited.

In order to form an opinion on these points, visits were made to as many as possible of the reported deposits of iron-ore, to the number of over forty, where, besides examining all openings, measuring all ore exposures and collecting illustrative specimens, both of ores and rocks, surface and magnetic surveys, were made in many places. The points visited, including many reported hæmatite occurrences, were as follows:—The Bluff Point and Calabogie mines of The Calabogie Mining Co.; the Coe mine; the Martel or Wilson; the Culhane; the Williams or Black Bay; and the Lerond mines, all in Bagot township, and within a radius of three miles of Calabogie station on the Kingston and Pembroke railway; the Radenhurst and Caldwell properties in Lavant township and near Flower station, and in the same township the Wilbur mine; the Robertson and Mary mines near Mississippi station in Palmerston township, all situated near the line of the Kingston and Pembroke railway north of Sharbot lake. Between this point and Kingston, the mines of the Glendower group were visited, namely, the Bedford or Glendower mine; the Howse mine and the Black Lake mine.

Of the district tributary to Kingston, by way of the Rideau canal, time only permitted visits to the two chief places, viz., the Chaffey and Yankee mines, near Newboro'.

In the south-western corner of Lanark county, the mines visited were the old Foley mine openings with those adjacent to it, and several reported hæmatite occurrence in Bathurst township. In Dalhousie township, visits were made to the old Playfair hæmatite mine and to a number of reported indications of the same mineral in that vicinity, as well as to one on the eastern shore of Dalhousie lake.

In the township of South Sherbrooke, the mines visited were the Christie's Lake; the Bygrove: the Fournier (with the adjacent Allan mine in North Crosby); the Silver Lake and others near Christie's

lake, whilst near Maberly on the Canadian Pacific railway in the northern part of the township, examination was made of the range of properties, taken up for iron, extending from near the station westward to the property of Mr. Rudd, in Oso township. Although somewhat distant from the present railway communications, a trip was made to the Yuill mine near the western end of White lake in Darling township. The above, together with reported hæmatite occurrences in Storrington township on Dog lake, which connects with the waters of the Rideau canal, on Birch lake in Bedford township, and some other points of lesser importance, constitute the localities it was found possible to visit as examples in the time at disposal.

General features of the district.

A glance at the accompanying general map of the district dealt with, shows many of its leading features.

Transportation facilities.

It covers an area of about 1,600 square miles, and along its length of about seventy miles, it is traversed by the Kingston and Pembroke railway, which is connected by short spur lines, with the more important mines. Crossing it and connecting with the above, are the Bay of Quinte railway system, and the main line of the Canadian Pacific railway between Montreal and Toronto. The Brockville, Westport and Sault Ste. Marie railway, would also connect with Kingston, either by means of the waters of the Rideau canal at Newboro', or by the all rail route through Brockville. Furthermore the navigable waters of the Rideau canal and all its ramifications through the series of connecting lakes, shown on the map, give water connection to many points in the district. Transport of ores from these points and of material to them can thus be effected by scows and small tugs. Steamers of moderate draft ply regularly on the main channel of the canal during the summer months.

In the case of deposits now situated, or subsequently discovered, on or near the shores of any of the other large lakes, transport by scows towed by small tugs, would often save wagon haulage of many miles. It will be seen also that the district is well supplied with roads. These, of course, are of varying degrees of excellence, the main routes being kept in good condition. In winter, the cost of transport is greatly reduced by the use of sleighs, as steep hills can be avoided and short cuts made by passing over the frozen swamps and lakes of the valley bottoms. The district is thus seen to be well provided in the matter of transport.

The very numerous lakes, creeks and rivers ensure a bountiful supply of good water, and also provide at many places, water-powers of vary-

Water supply.

ing importance. Falls of 100 feet or over, on large streams, occur at several points. Many of these water courses have been used for years for bringing lumber from distant points and this enlarges the possibilities of the timber supply of the district.

Timber.

The pine limits of this district have been worked vigourously in former years, and owing to this, and to extensive bush fires in places, they have seen their best days, still so much of the country is yet bush-covered, that for general purposes, small timber could be obtained locally in most cases. This would especially be true in regard to spruce, tamarac, etc., and the cedar of the numerous swamps found in the valley-bottoms.

Surface features.

The sections underlain by the palæozoic sedimentary rocks of the southern portions, coloured pink on the map, are fairly even and level and provide large tracts of good agricultural land. They are consequently largely cleared and settled. The Archæan country to the north, containing the mineral deposits, is more rugged, and, in places, is very hilly, the erratic courses of the roads evidencing the difficulties arising from this cause. In these sections numerous hills occur, often with steep sides and bluff faces, but without any very marked regularity or arrangement in definite ranges. They vary from one to several hundred feet in height, above the general level of the country, but none attain to the dignity of mountains, although often so designated locally.

There is a general rise all along the Kingston and Pembroke railway in going north until the summit is reached near Wilbur mines, at 907 feet above sea-level, from whence there is an average falling away in the direction of the Ottawa river valley further north. The highest hills in the district covered by the map attain to a little over 1,000 feet above sea-level or to about 754 feet above Lake Ontario at Kingston.

Settlement and farming.

The proportion of bare rocky uplands, is necessarily large, although the soil where it does exist in hollows, swampy lowlands and valley flats, is fertile. The farms and agricultural settlements, are numerous, although less extensive and more scattered than those further south, mixed farming being followed in the lower levels, while sheep-raising is successful on the higher and more rocky portions. Mining operations will therefore never encounter any difficulty or enhanced cost on account of either food or labour supply. Wages would be about at the rates paid elsewhere in eastern Ontario.

Wood fuel for mining purposes is obtained from the surrounding bush lands, which at most points ensure a plentiful supply. In the case of extensive and long continued operations, this would of course have to be drawn from continually longer distances, and in the end it might be necessary to import coal from the eastern United States.

It must be remembered that the area dealt with in this report is only that immediately tributary to Kingston, which could supplement its ore-supply by rail from other iron ore districts of eastern Ontario and adjacent portions of western Quebec, as for instance from the deposits near Ottawa, as well as from still more distant points both in Canada and the United States along the course of the navigable waters of the great lakes.

General geological features.

Geologically the district presents a series of gneisses, schists and various igneous rocks with associated limestone belts and areas. On the denuded surface of this series, which is classed as Laurentian, have been deposited the various sediments constituting the lowest beds of the Palæozoic series. The latter is encountered in passing southward, forming a continuous sheet, covering the older rocks. Northerly from the edge of the fossiliferous rocks, however, outliers of the same of varying thickness and extent are scattered widely over the country. In the basal sandstones and conglomerate beds of this fossiliferous series occur the hæmatite ores, whilst the deposits of magnetite, apatite, mica, etc., occur in the Archæan.

The Laurentian forms a complex made up of igneous rocks of gneissic and granitic structure and very variable mineral composition. These are accompanied by belts and areas of crystalline limestone. The general strike of the whole is north-easterly throughout the district and the dip south-easterly, sometimes at quite steep angles and sometimes lying comparatively flat. North of Calabogie at the Black Bay and Culhane mines, near Norway lake, the dip seems to be northerly, but the data obtained during the examinations made were not extensive enough to enable a judgment to be formed as to whether this was merely local or otherwise.*

Limestones.

The limestones are crystalline in structure, and frequently are quite marble-like in texture. They trend N.E. along with the general strike of the formation and show very varying widths of outcrop, which, whilst in part produced by changes in dip, is also due to irregularities in thickness. As in the case of the limestone areas found in the apatite region

* For the broader features of the geology of this section, see the forthcoming report of Dr. R. W. Ells, of the Geological Survey Department.

of Ottawa county, they carry inclusions of the associated rocks in greater or less profusion and amongst their contained minerals are decomposition products of the same. These inclusions help to mark the banding of the limestones, especially where brought into relief by weathering action. Quartzose streaks, bands and nodules, are amongst the commonest features of this kind. In some places over large areas, there is quite a distinct colour banding in gray and white, which, when accompanied by the marble-like texture, before mentioned, gives a value as an ornamental stone, for monumental and building purposes.

Excepting with regard to those sheets of water along the north-facing escarpment of the palæozoic rocks, these limestone belts and areas seem to have been a determining factor in the formation of the lakes, watercourses and valleys whose parallelism to each other, and to the trend of the formation, will be evident from an inspection of the map. Bays, points and chains of islands in the lakes are found to exhibit the same connection with the harder and softer belts. Although these rocks may, for the most part be rightly termed limestone, they possibly contain enough carbonate of magnesia in places to rank as dolomites. The data available are, however, insufficient to enable any conclusion to be arrived at in regard to chemical composition over any large district.

Gneisses, granites, etc.

Apart from the limestones, the great bulk of the formation is made up of material of such mineral composition as to affiliate it with the igneous class of rocks. The microscopic investigations as yet made into their nature is limited to too few determinations, to permit very definite conclusions. Those given in the appendix at the end of this report supplement the results of the field observations but they only justify general and tentative statements in regard to the matter.

Areas exist, often of considerable extent, of acidic rocks of coarsely granitic structure which may represent intrusive masses in the formation. Such a one was noted some little distance south from Calabogie along the Darling road. Many of the coarser grained basic rocks, probably gabbros, etc., of confusedly crystalline structure and without any sign of parallel arrangement of their mineral constituents, as at the Chaffey & Matthews mines, may also represent eruptive masses. A definite opinion as to the relationships of these more basic rocks to the rest of the series, could not be arrived at without much more extended field study, so that nothing further can be said as to whether they are merely basic members of the series or intrusive masses in it.

Apart from these, however, the great bulk of the formation would consist of rocks, varying in chemical composition from quite basic to more acidic members, and in structure from distinctly schistose to more thickly banded gneisses. The structure of the gneissic rocks is, as elsewhere in the Laurentian, of varying degrees from slightly marked parallelism, in the granitic gneiss, to the varieties with distinct bands of contrasting mineral composition marked often by quite acidic and distinctly basic alternations. Thus, thin sections of hand specimens are apt to reveal under the microscope simply local phases, and the realization of the grand aggregate of the mineralogical features of the whole formation yet awaits extensive and systematic petrographical research. Character of gneisses, etc.

A study of the data given in appendix A will give some useful ideas however as to their petrographical affinities, more especially of the members immediately associated with the magnetite ore-bodies.

It will be noted that we have representative amphibolite as at Bluff point and the Campbell mine at Calabogie, diorite at the Martel, Culhane, Christies Lake, Robertsville and Ritchie mines and altered amphibolite at the Bedford mines. Examples of gabbro-diorite are given from the Fournier, Bedford and Ritchie mines. Amongst the examples of the more acidic rocks are biotite-granite gneiss from Wilbur and augite-syenite gneiss and syenite from the Ritchie mine.

The basic rocks, amphibolites, gabbros, and diorites, are amongst the more intimate associates of the magnetite bodies. Among the associated minerals, the most interesting are apatite, pyrite, ilmenite and sphene, all having an evident economic interest, and, as bearing on the formation of the ore-bodies, we note the constant presence of alteration and decomposition products such as scapolite from plagioclase and hornblende, chlorite, etc., from augite, whilst calcite resulting from rock-decomposition is of constant occurrence.

Although no faultings of the formation were particularly noted or traced out, many such probably exist and affect the continuity of the rocks and chains of ore-bodies. An instance of these possible effects, has been noted in the case of the Wilbur mine of which a description is given later.

For particulars of work done in earlier years in this district by the Geological Survey, see:—The Geology of Canada, 1863, and the Reports of Progress for 1870-71, 1871-72, 1872-73, and 1874-75, wherein will be found the results of investigations made by former officers of the staff, together with descriptions of some of the ore-deposits. Most of the more important and largely worked deposits were not, however, discovered until after the publication of the above mentioned reports, and the descriptions given herewith are therefore the first ones which have been made.

Although the ores mined in this district so far have been almost altogether magnetites, in the past, the Dalhousie or Playfair mine shipped hæmatite for several years, and at many points in the district similar ore is reported as occurring, although it has nowhere else been developed to any extent.

Magnetite deposits.

Magnetite:—Regarding the district in general and its probable future ore producing capacity, a correct judgment could not be formed if the fact were ignored that the deposits are irregular in their nature. It would seem as if, so far, this feature had hardly been recognized sufficiently, and thus we find most observers in the past assuming that the ore occurs in beds, and therefrom erroneously inferring the continuity of the ore-bodies between widely separated outcrops, and in some cases forming most exaggerated estimates of the amount of ore which could be regarded as proved to exist.

Use of magnetic needle.

Then also in using the dip-needle, this same error would appear to have been frequent. If, for instance, on a given run of rock or direction across country, a few high dip-readings were obtained in a distance of several miles, it would be assumed as proved that a continuous bed of ore exists, only requiring sinking on it to open it up for extraction.

In travelling through the country opportunity was taken to point out, that by so using the dip-needle, comparatively little can be proved when, as in most cases, the observations have not been taken sufficiently close together to justify definite conclusions. Also, that all such conclusions must be modified and interpreted in the light of knowledge acquired by a study of the worked deposits and of their nature and peculiarities. For example, it was found that many of the worked deposits consisted of isolated masses of magnetite in compact, dark, basic (dioritic?) rocks, and many of the dip-readings were obtained along the strike of similar basic members of the series, where no outcrops of ore showed, leaving it to be concluded, in the absence of anything to the contrary, that these isolated dip-readings might be taken as showing the existence of separated masses of magnetite of greater or less extent rather than of a continuous bed of ore.

Other indications.

Another feature which has led to misapprehension in many cases has been the prevalence of outcroppings of rusty rock which have generally been taken as indicating the existence of iron ore below. As a matter of fact, the colour of these rusty parts seems to be almost always due to the decomposition of pyrites plentifully disseminated through the rock.

Whilst, however, all these points must be taken into account in judging individual deposits, the wide-spread occurrence of ore bodies throughout the district as a whole, and the great likelihood of further discoveries, leading to a large addition to the list of deposits already known, would seem to assure its future as an ore-producer capable of supplying any smelter of reasonable size that might be erected; just as in the case of the phosphate mining district of the Rivière du Lievre in the province of Quebec, where, whilst the deposits of that mineral show similar irregularity, the output of the district was considerable and steady for over seventeen years, and ceased only because of low prices, and in no way because of any failure with regard to its capabilities for yielding the mineral.

District in general as an ore-producer.

The mode of occurrence of the magnetite deposits may be briefly summarized as follows :—

Character of magnetite deposits.

The chief deposits which have been worked may be classified under three heads, viz.:—First, ore-bodies occurring at the actual contacts of belts of crystalline limestone with the harder gneissic and schistose members of the series. Second, ore bodies where the magnetite occurs in ribs, or impregnating schistose or gneissic belts, in most of which cases limestone is either absent from the vicinity altogether or only occurs at some little distance from the ore-body. Third, ore-bodies occurring entirely within areas of basic rocks, very much after the manner of the apatite deposits of Ottawa county, province of Quebec, where these are found in the pyroxenites. In the first and second classes there is a tendency for the ore-bodies to follow along the strike of the formation, either entirely isolated from each other or separated by intervening stretches of rock, either free from magnetite or too poor to pay for extraction. This tendency to follow the strike has been recognized by the local prospectors, and it will be evident by studying the map of the district and the plans of the mines accompanying the report. Where the ore occurs in the schistose rocks, the magnetite frequently shows itself as detached grains, plentifully disseminated through the substance of the schist, varying in proportion between the extremes of magnetite-bearing schist and ore with a small intermixture of bisilicate minerals.

The limited microscopic studies already made, seem to point to the probability that magnetite is, in any case, one of the constituents of the basic members of the formation as a whole, and many of the ore-bodies of economic importance may probably be the final results of processes of secondary concentration. Field studies certainly leave this impression, especially in view of the alteration effects noted in the immediate

vicinity of the ore bodies. Of such are the very frequent existence of chloritic envelopes and selvages, probably representing the local alteration of the bisilicate minerals of the surrounding rocks—the more largely crystallized mica and other minerals occurring under these conditions—the replacement of the plagioclase by scapolite—the alteration of pyroxene to hornblende, marked in approaching ore ribs —the presence of calcite in the rock and in patches, etc., apparently of secondary origin—the further breaking down of basic rocks into serpentinous masses in the vicinity of the magnetite, and the intermixture and interbanding of similar products through the ore itself.

In the third class mentioned above, the ore shows itself in detached irregular occurrences, the rocks being at some points reticulated by numerous veins, seams, etc., of magnetite, showing at times vuggy or drusy cavities, with crystals of calcite, hornblende and other minerals. The magnetite will thus vary very considerably in its occurrence, from places where there is a large admixture of foreign matter to those where the ore is in considerable mass, and comparatively pure. These features are possibly due to magmatic differentiation.

Size of ore-bodies

The developments made in the district in the way of proving the deposits, have been comparatively shallow in most instances, being limited to depths under 100 feet; although in a few cases, by means of pits and diamond drill holes the ore has been proved to a depth of 300 feet. Longitudinally, the distance between the extremes of any range of pits would come well within 2,000 feet for the most extensive mine in the district, while in most instances the known extent in length of any string of ore-bodies is covered by a few hundred feet, and frequently the whole development consists of one more or less circular pit.

As to the thickness of the ore-deposits, it is extremely variable even in the more regular belt like masses. At the same mine, it is found to vary from one or two feet up to 30 or 40 feet; whilst with regard to the more irregular deposits in the basic rocks, it would be impossible to actually say which dimension of the pit should be taken as the width. At Robertsville the extreme dimensions of the large pit were 200 feet in depth, 100 feet in length, and 55 feet across the thickness of the deposit. At the old Chaffey mine, there are three large pits, separated only by narrow walls of rock. They are said to be about 50 feet deep, and would measure, in the case of the two larger, 50 by 150 feet, and for the smaller, about 30 feet by about 150. At the Yuill mine there is a pit about 130 feet in length, reported to be 60 feet

deep. These examples will illustrate the dimensions of some of the largest of the irregular ore-bodies of the district. It is stated that the Robertsville mine shipped over 60,000 tons, which further indicates the size attained by such ore-bodies, and as it is stated that the three diamond drill holes put down on the hanging wall side went through twenty feet of ore, at a depth of about 350 feet, the body of ore evidently extends a considerable distance below the depth at which the work was abandoned.

In some cases nearly the whole of the material taken out has been shipping ore, as evidenced by the small mass of the waste pile compared to the size of the excavation, although in most instances the amount of waste has been considerable. In one case where a close approximation could be arrived at from the data available, the proportions were roughly one third waste to two thirds shipping ore. It might possibly run as high as half and half at some places.

Character of magnetite ores.

The magnetite ore of this district presents the following features. The shipping ore of course represents the best, as selected from the general run of the ore mined, and is in general pretty free from sulphur as far as visible pyrites is concerned. The various piles of ore examined, with very few exceptions, showed no visible apatite. Beyond this, no further statement can be made as to the percentage of sulphur and phosphorus which might be expected in the ores of the district taken as a whole, and in large shipments, short of spending considerable time and money in really sampling large piles. That the percentage of these deleterious ingredients does not prevent the use of the ores in the blast furnace under proper conditions, is evidenced by the fact, that as long as the prices permitted their exportation, the United States smelters were quite willing to buy and use them.

The ore-bodies do carry pyrite and often in considerable quantity, but in most cases in such a way that the pyritous parts can be rejected by hand picking. At some points visited, however, the pyrite was so finely and evenly distributed throughout the ore as to render its elimination by this simple process impossible, and this has also been found to be the case in portions of some of the larger and better known deposits which have elsewhere yielded large quantities of clean shipping ore. In the case especially of some of the isolated occurrences in the basic rocks, apatite occurs associated with magnetite, mention being made of such later in the report.

As shown by the ore piles, the foreign matter which would have to be dealt with in smelting would be mostly of a fusible nature, consist-

ing of hornblendic, micaceous and chloritic material distributed through the mass, as well as in the seams in the ore. Calcite is also a common ingredient, with more rarely quartz. These minerals, by proper selection, should make a good slagging mixture.

In grain, the ores at different points show varying characters. Those of the ore-bodies in the basic areas are apt to show a peculiarly vitreous fracture, vuggy structure, and interferent crystalline aggregation of the magnetite; whilst at other points the structure of the ore is schistose, platy or granular, with a coarse or finely crystalline cross fracture.

The examination made of the ore-piles of the district showed a visible admixture of foreign materials, already mentioned, of from five to fifteen per cent, estimated by the eye. This would of course bring down the theoretical percentage of iron in the magnetite (72·37 per cent) to from 60 to 65 per cent.

Chemical constitution of ores.

A table has been prepared of all the available analyses of the iron ores of this district and is given at the end of the report (Appendix B.) With a few exceptions it represents analyses made at various times in the laboratory of the Geological Survey and published in the reports, and includes the analyses of the series of specimens collected during the field examinations undertaken for the purposes of the present report. With one exception, these analyses are all of hand specimens and can therefore only be taken as giving a general idea of the composition of the ores. However the following statement based upon the existing information may be given :—

Of the 65 determinations of metallic iron, 49 were of magnetites and 16 of hæmatites, the average of the former being 57·03 per cent, of the latter 55·25 per cent. If, however, we eliminate those specimens which gave over 15 per cent insoluble matter as not representative of shipping ore, the average percentages become 59·53 for hæmatite, and 59·08 for magnetites, the latter agreeing closely with the analysis of the average sample from Bluff Point mine, marked in the table with reference letter—A.

Of the 37 determinations of phosphorus in the magnetites, that element varied from a trace to 0·17 per cent, the latter amount occurring in the average sample—reference letter A. In one specimen, although this element was not determined, small crystals of apatite were visible to the eye. The average was 0·022 per cent. In eleven hæmatites this element averaged 0·077 per cent, owing to a few specimens which ran exceptionally high, notwithstanding that 7 of them ran below 0·05 per cent. The extreme range lay between 0·004 and 0·3

per cent. It is curious and interesting to note that the magnetites, occurring as they do in rocks so frequently containing apatite as a microscopic constituent, and in a formation throughout which so many economic deposits of that mineral have been worked, average lower in phosphorus and show less variation in that respect than the hæmatites whose conditions of occurrence would hardly lead one to expect such a feature. Chemical Constitution of Ores.

Ten of the assays of magnetites give returns of sulphur contents ranging from a trace to 1·75 per cent and showing an average of 0·58 per cent. This is considerably higher than that of the analysis of the average sample—reference letter A. which shows 0·17 only. In four hæmatites, the sulphur returned ranges from 0·004 per cent to 0·7 per cent and averages 0·037 per cent. Titanic acid was looked for in two hæmatites, but it was not found. In the 25 examinations of magnetites, this element was proved to be absent in thirteen cases; present but not determined quantitatively, in two others, and in the ten other cases present, in percentages varying between 1·03 and 16·45. The extreme variableness of this constituent is evident on reference to the tabulated analyses. For instance, in the specimens from the Chaffey and Yankee mines, whilst one showed but a trace, others ran as high as 12 and 16 per cent. There seems to be a generally higher average, as might be expected, in ore occurring as these do in a coarse very basic rock (probably an intrusive gabbro).

Thus it may be stated that in so far as these analyses represent the general character of the ores, the percentage of phosphorus averages low, the sulphur is in some cases rather high, while the titanium, with a few exceptions, is inconsiderable in amount. Should it be found advantageous in some cases to do so, the amount of sulphur might no doubt be reduced by roasting and by careful selection. It is unfortunate that neither the time nor means at disposal permitted of the gathering of samples representing large quantities of selected shipping ore, so that the one analysis of an average sample (reference letter A) is all we have of this nature. In order to arrive at a reliable conclusion as to the quality of ore the district is capable of providing, and in view of the variable nature of the deposits, such sampling would also have to extend over long periods of time without which it is not possible accurately to determine what proportion of phosphorus, sulphur or titanium would actually have to be dealt with in furnace charges or to what extent it might be advantageous to mix these with other ores. The ores of the district have been used already by managers of smelters in the United States, presumably in this way and lately,

also, the Canada Iron Furnace Company, in the province of Quebec has used these ores for admixture with their own bog ores. The constant improvements in methods of smelting in late years have of course rendered it possible to utilize more impure ores than formerly and even in making the best kinds of steel a much lower grade of pig can be used.

Shipments of Ores.

It is stated that in the past the total shipments from this district have amounted to some 250,000 tons of magnetite, to which must be added about 30,000 tons from the Dalhousie and McNab hæmatite deposits.

Hæmatite Deposits.

Hæmatite.—A number of points were examined where deposits of hæmatite were reported to occur, with a view to ascertaining the possibilities of obtaining supplies of this class of ore. Apart, however, from the old Dalhousie or Playfair mine in Dalhousie township, nothing was seen that could be properly described as a hæmatite deposit. In some cases the only indications consisted of pieces of hæmatite, either lean or rich, ploughed up in fields; at others, an ocherous impregnation of the rocks or soil had led to the belief that the prevalence of so much rusty material must indicate the existence of solid hæmatite in depth. In every case, however, a little investigation of the surroundings would demonstrate the connection of the phenomena with the occurrence of outlying patches of the *basal beds of the sedimentary series. Where this formation showed distinctly, it would appear as if the supposed hæmatite deposits consisted of shattered portions of the sandstone, the spaces between the broken pieces being filled up with loose ochreous oxide of iron, which had also percolated into and filled the interstices between the grains of the sandstone, thus giving the whole a very rusty appearance. In places, specimens could be obtained of the solid hæmatite; but these, judging from all appearances, probably owe their condition to a further consolidation of the original loose ochreous form of the oxide. This action, however, has only gone on to a limited extent, nor did it seem likely at any of the particular points visited that any large quantity of the richer and more solid material would be obtained. The bulk of the material, wherever seen, consisted of sandstone impregnated or stained with ochreous oxide of iron to a greater or less extent, constituting at best a very lean ore.

It was found impossible, in the time at disposal, to visit all the reported occurrences of hæmatite, but in most cases, from the descrip-

* The age attributed to the outlying patches of these rocks, viz, Potsdam or Calciferous, is probably correct in most instances, although at places distant from the present edge of the Palæzoic and at higher elevations, they may represent shore deposits higher up in the series, their position being due to overlap.

tions given, it is evident that they are similar to those noted. In the report of the Royal Commission on the Mineral Resources of Ontario, pages 128 to 142, many such places are mentioned, and at one place viz., Tamworth, a number of shallow pits had been put down, which proved the superficial nature of the deposit, and that it was underlain by crystalline limestone. The quality of the ore here is said to have varied also from rich to quite lean. Character of Hæmatite Deposits.

The Geological Survey called attention, years ago, to similar occurrences in the Potsdam* at other places, as will be seen by referring to the Geology of Canada, pages 88 and 89, and the dolomitic nature of this formation in places was also alluded to.

Taking everything into account, it may be assumed that the phenomena observed are the result of the decomposition of ferruginous dolomitic parts of these sedimentary rocks, with the formation of ochreous oxides of iron and further consolidation of the same in spots into the hæmatitic form, the lean ores consisting of adjacent portions of the sandstone impregnated with the ochreous decomposition product.

In a few cases the ore was found apparently passing down into the underlying Archæan rocks, but evidently to a limited depth only, and in such a way as to lead to the belief that these cases resulted from percolation downwards from the overlying rocks into joint-planes and cavities.

Of those visited, the Dalhousie mine is the only one having any features of a continuous ore-body. The interesting point about this mine, lies in its being a body of ore extending downwards for a known depth of 100 feet into the crystalline limestone. It is suggested, however, that it simply represents ferruginous material leached out from the originally-overlying sandstones, etc., deposited in a waterworn cavern in the underlying limestone. This view is borne out by several features observed on the spot, and is shown in the plan and sections of the mine already alluded to, viz., the irregular shape of the ore-body; the fact of its continuing eastward underground without cropping, being in fact entirely overarched by limestone; the smooth limiting surface between the ore and the limestone; the tendency of the body to show a general lense-shape and to thin out gradually in depth. This thinning out in depth is also mentioned as a feature of the Arnprior deposit in McNab township, which occurs similarly in crystalline limestone. Dalhousie and McNab mines.

From the published description of this place, it would seem to be very similar to the Dalhousie mine. It is said to have been worked

to a depth of about 80 feet, when, according to one account, it thinned out, and according to another it was cut off by a fault.

Bog Ores.

Bog Ores.—No deposits of bog iron ores were visited, but the existence of these is reported at a number of places in the district.

General Conclusions.

Summary.—Reviewing the results obtained by the investigation and having in view the answering of the questions propounded, the conclusions arrived at may be stated as follows:—

There seems no reason to doubt the possibilities of the district in the matter of supplying ore for a smelter of the size contemplated (viz., 100 tons per day) providing exploratory and developmental work is kept well ahead of the actual work of the extraction of the ore, for although the ore-deposits are irregular in their nature, yet the occurrences already known are numerous, and doubtless many others would be located by explorers, were a demand to arise for the ore.

Apart, however, from the general chances as above set forth, the question of ore immediately available must remain in abeyance, as naturally no measurement of 'ore in sight' could be made with most of the mines abandoned and full of water. The ore supply would be almost entirely magnetite, with possibly some hæmatite or bog ore. In the magnetite, careful selection would probably be necessary in the case of some of the deposits in order to keep the proportion of sulphur low.

PART II.—MAGNETITE DEPOSITS.

Parts II. and III. following give the detailed descriptions of the various iron-ore deposits examined in the field during 1895 and 1900 and supplements the foregoing general report on the district given as Part I. which appeared in substance in 1896 as before stated.

GLENDOWER MINE.

Bedford Township, Con. II., Lot 6 and Con. III., Lot 6.

Glendower Mine.

This mine is situated within four miles of Bedford station, on the Kingston and Pembroke railway, with which point it is connected by a branch line. The main workings are on Con. II., lot 6, and Con. III., lot 6, near to the west shore of Thirty Island lake.

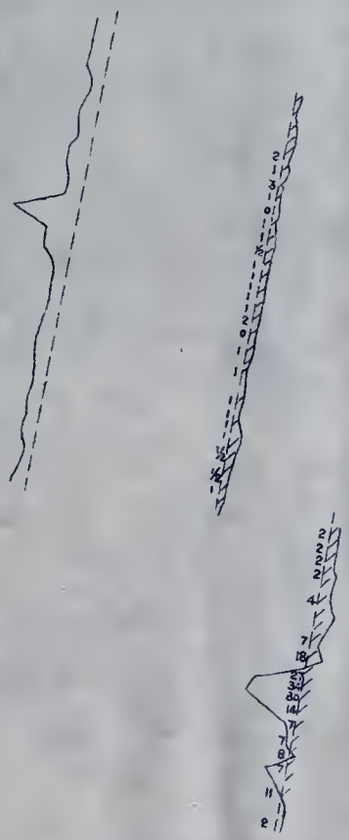
The ore-bodies developed in the workings are in gneissic rocks immediately at or near their contact with a belt of crystalline limestone.

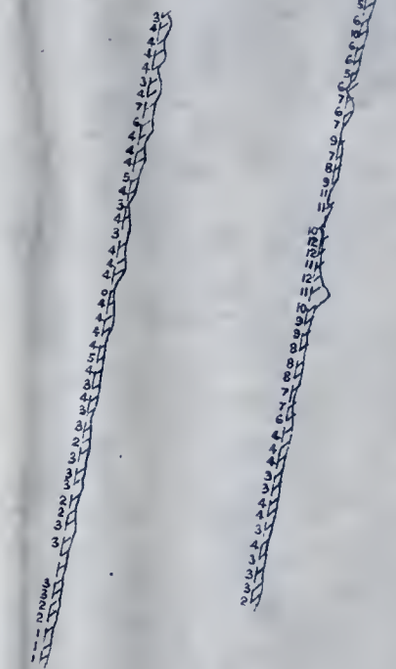
EXPLANATORY NOTE.

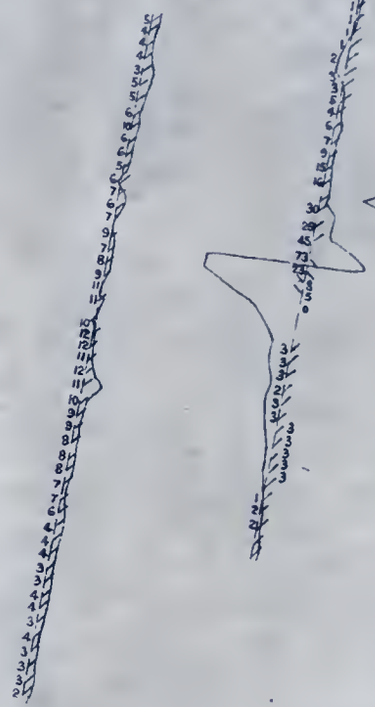
Readings of the dip-needle plotted as curves.

Deflections of the horizontal needle shown thus:

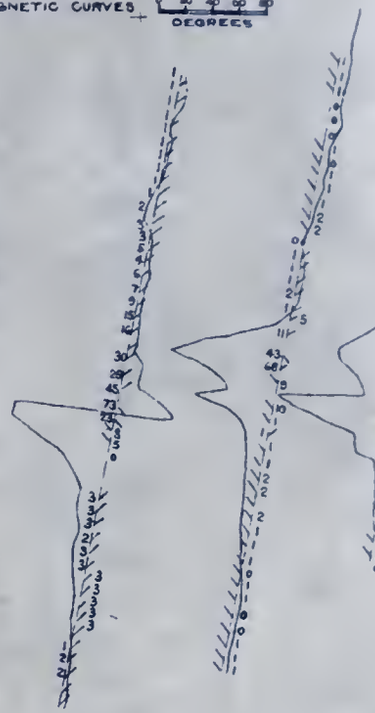
meaning 50° N.E.—30° N.W.—20° S.E.—10° S.W.







SCALE FOR MAGNETIC CURVES 10 20 30 40 DEGREES



BEDFORD OR GLENDOWER MINE.
FRONTENAC COUNTY.
ONT
LEGEND
DIAMOND DRILL HOLES
N E I S
LOT No. 6
LOT No 5
L I M E S T O N E
Approximate Northern Limit of Limestone
Low ground
Test Pits
Mine Buildings
Boarding House
B E L T
THIRTY ISLAND LAKE
Approximate Southern Limit
GNEISSIC ROCKS
Shaft No 1
DIAMOND DRILL HOLES A B C C1 C2 & D.

The latter rock outcrops extensively to the south of the main workings, occupying all the interval between them and the arm of the lake, which runs parallel with the line of the pits, and about 600 feet south of them, in a westerly direction, for about three-quarters of a mile. Immediately to the north of the workings the gneissic rocks of the series are largely developed. These as a whole represent the varied character usual in this formation ranging from pale-coloured acidic and intermediate rocks to very dark heavy basic members. An area of the latter occurs north of the eastern workings. It is roughly triangular in shape being about 500 feet wide at its eastern end and tapering to nothing at a point about 500 feet west of No. 5 pit. No sharp delimitation is evident on the ground between this area and the gneisses of more normal composition to the north, of which it probably represents a localized basic phase. Glendower Mine.

This area while generally basic in character, and apparently largely composed of hornblende coarsely crystallized frequently presents a largely mottled appearance from the existence of concentrations and veins of black coarsely crystallized hornblende traversing a lighter coloured base consisting of hornblende crystals with a waxy looking mineral of felspathic appearance. The latter portion of the rock is more easily decomposable than the darker parts. In the hornblendic veins vuggs occur at times which are lined with well formed crystals of the same mineral. In places this basic area presents fine-grained compact dark-brown rocks very rotten and decomposed.*

Pyrite seems to be very plentiful at places and its decomposition evidently causes the general rustiness of the rock exposures. Calcite particles and efflorescent sulphate of iron are also common occurrences. The northern contact of the limestone with the gneiss is very distinctly traceable along the south side of pits Nos. 1, 2, 3, 4 and 5, as shown in the accompanying plan.

The actual contact is not visible west of this point, but from the way the rocks outcrop from beneath the cover, it must run in a direction approximately W.S.W. passing north of pit 6. The limestone crops out with frequency, forming a ridge between the last mentioned point and pit No. 8 on the adjacent lot to the south, where the basic rocks show again. It has thus an apparent breadth of outcrop of some 800 feet, which would represent a thickness of about 650 feet taking the actual width of the outcrop shown of pit 8, as above, and the dip at that point to be about 55 degrees. The southern limit of the belt as

* For particulars of the microscopic characters of these rocks see Appendix A, specimens Nos. 11, 12, 13 and 14.

Glendower Mine.

marked on the plan is worked out on the basis of the above thickness taking into account the various dips.

Commencing at the easternmost, or main pit, close to the shores of the lake the details observed were as follows :—

Pit No. 1.—This working consists of an open cut run in a westerly direction into the hill, in the gneissic rocks at their contact with the limestone. At its lower or eastern end it is opened out to a width of about 30 feet and gradually narrows to about a yard wide at its western end, where it ends as a shallow trench along the contact.

At the wide mouth of the open-cut, the main shaft has been sunk, which, at the time of closing the mine previous to our visit, is said to have attained a depth of about 180 feet. It is said that this shaft has been considerably chambered out and that some drifting and cross-cutting was done at the lower level. The outcrop of the ore-body on which this working has been made seems to have thinned out in passing west. A number of small test pits had been made between this and working No. 2, but no ore was observed in them.

Working No. 2.—This is but a short distance to the west of the west end of the last. It is a large open pit opened into by an open-cut running south-west into the hill the whole working being excavated in the gneissic foot-wall rocks, the limestone hanging wall forming its southern side. It is opened out about 70 feet along the strike of the deposit, and is about 40 feet wide and perhaps 30 to 35 feet deep from the top of the hill. In the south-west corner of the pit is to be seen the mouth of an incline evidently sunk on the dip, and close to the contact. The depth of this is however unknown.

The walls of the open pit show a coarse hornblendic rock, much stained with rust evidently arising from the decomposition of the pyrite visibly present. The ore seemed to be represented by several stringers of magnetite a few inches thick, so that whatever body there was at this point must have been taken out and the work stopped in comparatively barren ground.

Workings No. 3 and 4.—At these points nothing particular was noted. The former is a shallow, open prospect trench, and at the latter is a shallow surface pit, from the bottom of which has been sunk a small shaft said to be 100 feet deep. They are both in the brown, rather rotten, gneissic rock, the limestone contact showing on the south side of No. 4.

Working No. 5.—Is a long open pit close to the track. It is mostly filled with debris. The rock is dark-brown, earthy and decomposed,

showing in places magnetite in grains. Some small ribs of that mineral are occasionally to be seen penetrating the rock. At one point in the pit a little solid ore outcrops through the debris, showing for a foot or two in length and about the same thickness. Between this pit, however, and No. 2, a number of little prospect pits in these same rotten, brown earthy and rusty rocks seem to indicate an attempt to find workable ore between the two points. In picking all around I obtained occasional bits of good ore, and often the rock on fresh fracture, was seen to carry disseminated grains of magnetite.* Glendower Mine.

Working No. 6.—Consists of an open cut 15 feet in depth, of irregular shape in the side of a hill of limestone. A pit sunk at the eastern end is said to be quite deep. Good ore is reported as having been encountered in the bottom. An examination of the walls of the excavation shows irregular, flat-lying tongues of ore, associated with decomposed rocky matter, apparently originally similar to some such basic rocks as are associated with the ore in the eastern pits. Where worked out in the main workings, the ore is said to have a thickness of from 20 to 40 feet.

Working No. 7.—Is a little test shaft down about 25 feet showing no features which could be noted without making the descent, for which, there were no means available.

Pit No. 9.—At this point occurs a very interesting ore-body consisting of magnetite and apatite in about equal proportions in a gangue of calcite. It occurs in the more acidic gneissic rocks some little distance north of the run of the other ore-bodies and as described, its mode of occurrence is quite different. The pit is about 25 feet deep, and the ore-body which was small was altogether worked out. The test pits shown did not expose any more ore, but proved only the extension for some distance eastward of the calcite vein in which it occurred. This was mined to meet a demand for phosphatic ore for the Hamilton smelter.

---

* Since the above was written some further work has been done at the points numbered 5 and 5*a* on the plan, and ore has been extracted and shipped. The excavations are altogether in the same dark-coloured rock which at places was found to contain coarsely crystallized aggregates of hornblende crystals. It evidently represents a decomposed portion of the surrounding basic area. A small rib of limestone from a few inches to a foot or two in thickness occurs at this place, having the usual strike and appearing in working 5*a* and in the S.W. corner of working 5.

Working No. 5 consists at present of an open-cut alongside the track, about 150 feet long, averaging 40 feet wide and about 10 feet deep to the surface of the water. At its western end is a little pit about 15 feet deep. At No. 5*a* is an open cut into the north face of the ridge, with a shallow pit in the S.W. corner.

Glendower Mine.

Diamond Drill Borings.—Subsequent to the closing down of the mine previous to our visit, a series of diamond drill holes were bored from the hanging wall side which it is stated proved the existence of considerable ore below the old workings. These are marked A., B., C., C^1., C^2. and D. on the accompanying plan, and on the vertical section given there.

The four right hand columns in the following tabulation of particulars regarding these drill holes have been compiled from the description of the work given in the Journal of the Canadian Mining Institute, vol. I., part I., pp. 205–6. The reference letters coincide with those adopted in the accompanying plan of the mine, the holes having been simply described in their order in the publication quoted.

Particulars of bore—holes made with the Diamond Drill at the Glendower Iron Mine.

Designation of hole on Plan.	Direction.	Angle.	Depth.	Rocks, etc., Encountered.	Remarks.
		°	feet.		
A.	N.	80	182·5	Crystalline limestone; hornblende ; granite and quartz successively pierced. Ended in large drift from old shaft.	The rock formations pierced were limestone and granite with bands of hornblende and quartz. Holes C., C^1, and C^2. al drilled with the machine on the same site.
B.	S.	75	702	Boring being almost parallel to ore-body the latter was not encountered.	
C.	N.	70	197 to 280	Through ore formation for 83 feet.	
C^1.	N.	78	270 to 445	Through 175 feet of ore formation.	
C^2.	N. 10° W.	78	295 to 450	Ore formation cut across.....	
D.	N.	85	0 to 425	Chiefly limestone.....	
			425	Ore body first encountered.....	
			525	Hole finished on quartz.....	

From the data given in the publication referred to and by reference to the plotting of the same on the plan of the mine, several interesting features are brought out. *Hole A.* simply gave a measurement by which the average dip of the hanging wall of the deposit at that place can be ascertained. This would seem to be at an angle of about 76°, although the dip of the wall taken at surface measured 80°. *Hole C.* is said to

have passed through 83 feet of orey formation. Taking the average dip at that point from the surface down (78°) this would represent a thickness across the formation of about 45 feet. The outcrop of actual ore, however, does not show this width at surface, so that the deposit lacking definite limitations, it is difficult to arrive at a close estimate of the actual thickness represented by the orey ground penetrated. The fact remains, however, that irregular as the shape of the ore body may be, both this hole and the next cross it at an acute angle so that the thickness will be much less than could appear to be shown by the cores. *Hole C.* being at a steeper angle necessarily cuts the ore body so as to pass through a much greater distance in traversing its width. Even allowing for this, however, the 175 feet of ore formation reported shows either an appreciable thickening or that the body dips more steeply below the point at which it is pierced by hole C. *Hole C.* 2. cutting the plane of strike of the ore-body at an angle should show a greater length of ore ground traversed than in the case of the previous hole. The amount reported is, however, less by some twenty feet so that it would look as if there was a thinning out in passing westward. This surmise seems to find some corroboration in the results obtained further west again in hole D. At this point the ore ground traversed is reported at but 100 feet, which taking an average dip of about 80°, would be equivalent to somewhere about 25 feet of thickness. In all such interpretations the great irregularity of these deposits in every respect must however be borne in mind. Lacking definite boundaries, the mere fact that the last few feet of a hole were through barren material, does not by any means justify the assumption that the limit of the deposit has been reached and it seems a pity that the holes bored were not carried for quite a distance into the footwall rocks in order to prove the presence or absence of parallel ribs of ore. The 700 feet bored simply parallel with the formation at point B. might more profitably have given two flatter holes at C. and D. cross cutting the whole.* Glendower Mine.

Magnetic Readings.—So far as these were carried out the results attained are illustrated by the curves, etc., shown on the plan. The time at disposal did not allow of readings at sufficiently close intervals to enable the minutiæ of the distribution of the bodies of magnetite to be worked out, but some general conclusions can be drawn. It will be seen that the area of considerable magnetic disturbance is practically coincident with that of the very basic rocks extending some dis-

* Judging from the data given on a sectional drawing of these holes lately obtained from Mr. Jos. Bawden, of Kingston, the existence of a rib of pure ore 20 to 30 feet thick was proved, the rest being orey ground.

Glendower Mine.

tance north of the limestone contact between pits Nos. 1 and 5. At the eastern end this area of magnetic disturbance would have a width of about 350 feet narrowing down to about 200 feet along the line of observations crossing No. 5 pit. This does not, of course, represent the actual width of the ore-bearing zone as the needle is necessarily affected by the ore-body for some distance on either side. This will be seen by reference to the curves on the plan where the lines of observation approach the pits from the limestone side. The magnetic results obtained along the lines to the west of No. 5 pit would seem to point to the absence of any chain of ore-bodies between the eastern pit and the workings Nos. 6 and 7. These lines being about 400 feet apart there might of course be some small bodies along the contact in between them.

Ore shipments, etc.—Close to the track where it passes the main shaft at No. 1 working there was at the time the mine was visited a pile of several hundred tons of ore. In this it was noted that pyrite and calcite were considerably in evidence and an eye estimate placed the admixture of foreign material at about 10 per cent. In the evidence regarding this mine given before the Ontario Mineral Commission of 1888, it is stated that the ore shipped from the mine ran from 50 to 60 per cent in iron contents. When it was being worked by the Glendower Company, they, having a long wagon haul to their shipping point, sent away no poorer ore than 60 per cent. It is further stated that the Zanesville Company, having built a branch line, could ship directly from the mine and that the percentage of ore ran as low as 50 per cent iron. From the same source it is learned that the ore first obtained was free from sulphur, but that this constituent in deleterious quantity was encountered at a depth of about 180 feet.

According to Mr. Bawden, of Kingston, who has been connected with mining in the district for years, this mine shipped about 50,000 tons of ore up to 1895.

History of the mine.—The following items relating to the history of the work done at this mine are gathered from the evidence of Mr. J. Bawden, given before the Ontario Mineral Commission, before mentioned.

After some years of development work by the first owners, the Glendower Company was formed in 1873, who not only paid down a sum for the lease of the mine, but also twenty cents per ton royalty. They mined for seven years, at the end of which time they gave up the lease. This Company had a capital of $50,000, largely subscribed by

furnace owners of Elmira, N.Y., to which place they took the ore and professed themselves well pleased with it. Glendower Mine.

About 1883, in the fall, the Zanesville Company was formed of capitalists of that place and of Cleveland, Ohio. They constructed the branch line to the mine, and operated on a large scale with extensive plant, for four or five years. The capital of this Company was $200,000. In 1887 this Company was merged in the Kingston and Pembroke Mining Company, which, with a stock capital of $400,000, took over this, and a number of other mines, in the district.

At the time of our visit in 1895, the mine had been idle some years.*

Bedford Township, Con. II., Lot 5.

At the bottom of the bay which runs in south of, and parallel to, the Glendower range of ore-bodies, is a small prospect pit from which some magnetite has been obtained (See working No. 8 on the plan). It is interesting as showing the occurrence of ore near the other contact of the limestone belt along the northern side of which lie the workings previously described under the heading of the Glendower mine. As there mentioned, the limestone outcropping shows a width of about 600 or 700 feet. The little prospect pit is only about four feet deep, in the bottom of which is an exposure of ore, measuring about twenty-five by fifteen feet. Bedford II.,5.

Stripping and trenching has been done all around the pit, evidently with the intention of determining the direction of extension of the ore-body. Nothing definite, however, seems to have been proved by the work. In one of the trenches about thirty feet to the north of the pit, some coarsely crystallized hornblendic rock is shown.

At the pit the ore seems to be overlaid by a decomposed, dark-green rock, with parallel seams of a lighter green material. It has the appearance of dipping slightly southward. The ore shows similar parallel seams of the light-green material, and its resemblance to the inclosing rock in this and other respects leaves the impression that it represents a highly magnetiferous portion of the same.

A little pile of ore has been set aside measuring about ten tons. It carries a considerable proportion of intermixed foreign material,

* At the time of the examination made in 1900, the mine was also idle although it had been leased during the previous year to the Hamilton Smelting Company, of Ontario, who had done some little work around pit No. 2 and had opened up pits Nos. 5 and 5a.

amongst which calcite is observable, and pyrite, the latter fairly frequent.

The magnetic curves given on the plan, of the observations made with the dip needle at this point speak for themselves.

HOWSE MINE.

Bedford Township, Con. I., Lots 3 and 4.

Howse Mine.

About a mile and a half to the south-west of the last mentioned, are some pits which are known by the above name. No examination was made of these, but they are of interest as showing the extension of the chain of ore-bodies on the south side of the lime-stone belt. Mr. Jas. White of the Survey staff, when making the surveys for the map accompanying this report, made notes also of the geological features, in some parts of the district. He found the westward extension of the Glendower limestone belt to run to the north of the pits. It is said that considerable ore was shipped from this point.

BLACK LAKE MINE.

Bedford Township Con. IV., Lot. 8.

Black L. Mine.

About a mile and a half north-east from the main workings of the Glendower mine, on the point of an island in Black lake, a slight amount of work has been done on an occurrence of magnetite. At the place visited was a small open cut running into the side hill having a face of about 10 feet at its deepest point. The dip of the rocks seems to be flat, say from 25 to 30 degrees southward. No foot wall is visible but about 10 feet thickness of rotten schistose orey rock, shows. Much of it exhibits a speckled fracture, from the intermixture of grains of magnetite with some decomposable matter which now appears simply as a pale yellowish earthy material. In some places the magnetite grains preponderate largely, and are even consolidated, thus constituting the solid 'ore.'

All the rocks around are so rusted and rotted, that it would be impossible to make out their exact nature. This appears to be due to the decomposition of pyrite which is very plentifully distributed throughout their mass, on the hanging wall side of the pit. A black, scoriaceous-weathering rock, forms the shore of the lake, which at a few places shows as yet unaltered, largely crystallized, dark hornblende,

similar to some of the rock exposures at the Glendower mine and on lot 5, Con. II., before described. Whether the ore at this point, is near the northern or southern contact of the limestone belt, could not be determined in the time at disposal. Black L. Mine.

Near the opening just described is a little pile of some 50 cub. ft. of lumps of ore. It carries a very large percentage of intermixed matter in which calcite patches are prominent, and what appears to have been a bi-silicate mineral but which is now decomposed, is present in grains. Finely disseminated pyrite is also very plentiful. These were the only workings it was found possible to visit.

It is said that it was leased to a company from 1882 to 1884 who took out from 3,000 to 4,000 tons on a 50 cent royalty.

Mr. Bawden, in his evidence before the Ontario Mineral Commission, says :—"The Black Lake property was under prospecting lease to the Bethlehem Mining Co. and some 50 tons of rich ore have been taken away. At the time it was under lease, there were great difficulties in the way of transportation; since that time, a canal has been cut from Thirty Island lake to Black lake.....and the ore can be brought down to the permanent track at Thirty Island lake.

Bedford Township, Con. III., Lot 3. Bedford, III., 3.

Some small test pits and strippings have been made on magnetite bodies on this lot and a diamond drill hole has been sunk to a depth of about 300 feet. A large development of basic Laurentian gneiss occurs in this vicinity, in which are isolated bodies of magnetite of varying size.

An interesting occurrence of apatite of small extent had also been found in the same rocks a little distance from one of these magnetite bodies.

MISSISSIPPI OR ROBERTSVILLE MINE AND MARY MINE. Robertsville and Mary Mines.

Palmerston Township, Con. IX., Lots 3 and 4.

The Robertsville mine is connected with the Kingston and Pembroke railway by a short track of about a mile in length, and when working the ore could be hoisted from the main pit and dumped directly into the cars.

The pits of the Mary mine are close by on the adjacent lot.

Robertsville and Mary Mines.

The mode of occurrence of the ore-bodies in this place contrasts with that at many other localities in the district in that there is no limestone in the immediate vicinity nor connected with them.

The rock immediately inclosing the ore is a dark, compact, heavy basic rock, probably diorite which seems to extend for a considerable distance around.* Whilst in the field-examination, no gneissic structure was noticed except in a few places where it seems to be slightly developed, the hand specimens brought back seem on closer examination to have some parallel structure. The rock exposures around the mine show an irregular, pink, felspathic veining, and a light-green mineral probably epidote is frequently seen in patches. On examination of the hand specimens, pyrite seems to be fairly plentiful throughout the rock and in one of the small felspathic veinlets, octahedra of magnetite could be seen; epidote occurring in the same veinlets.

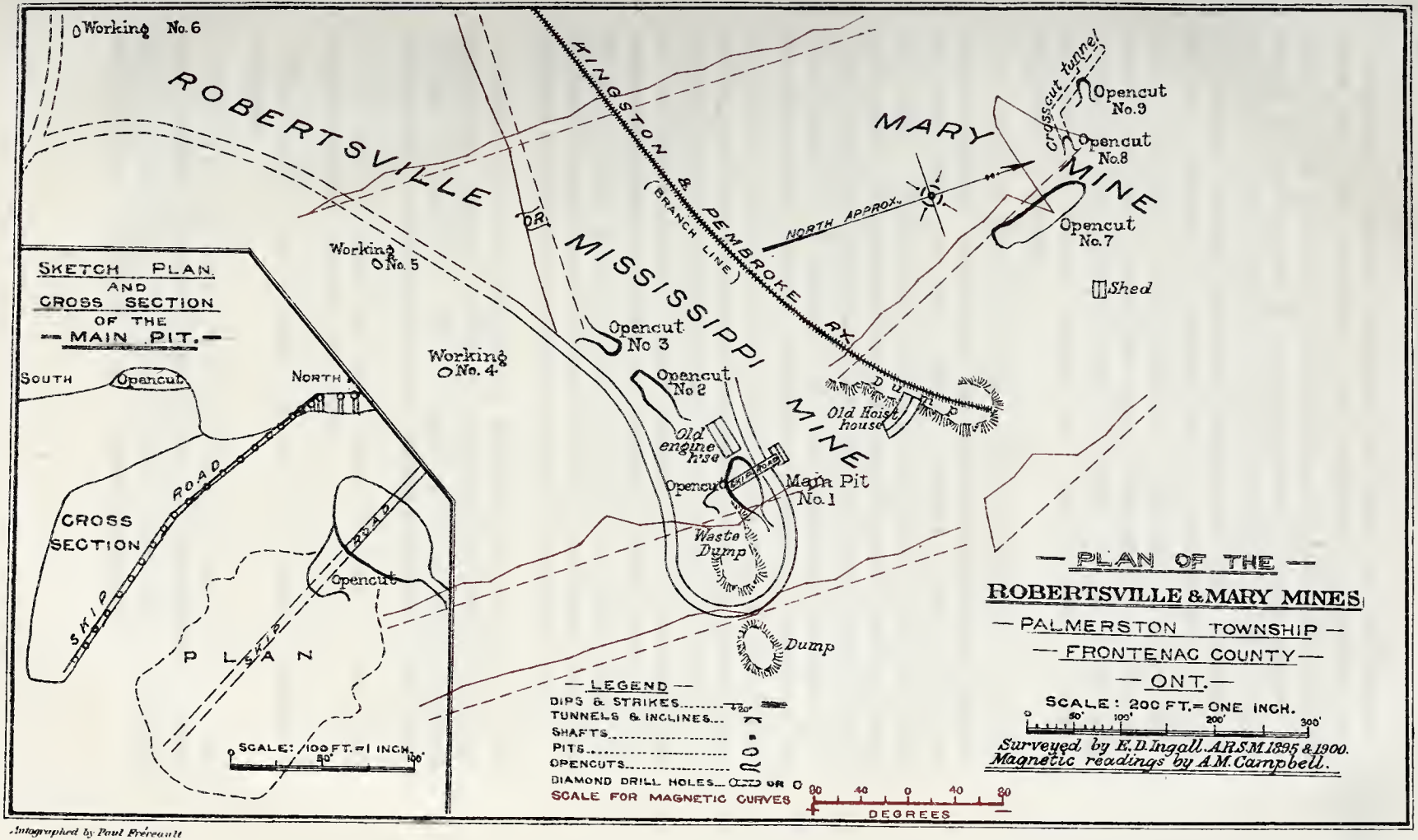
The developments consist of the main pit, a couple of shallow open-cuts near it and two small pits at some little distance from the large working. The accompanying plan shows the relative positions of the various openings and other features.

Working No. 1.—This is the most extensive. It consists of an irregular opening about 200 feet deep with an extreme longitudinal dimension of about 108 feet, the ore having been worked out to a thickness of over 50 feet in places. The excavation is simply a large irregular pit as will be seen by reference to the sketch plan and section given in the accompanying illustration, which also conveys a good idea of the irregular size and shape of many of the ore-bodies worked in this district. The average dip is seen to be about 52° southerly. The existence of ore at a depth of about 140 feet below the bottom of the pit is said to be proved by a diamond drill hole which was put down on the hanging wall side at an angle of 65°. Two other holes about 100 yards south of this pit and about 100 feet apart are said to have attained a depth of over 500 feet, and to have passed through 20 feet of ore.

Working No. 2.—About 100 feet to the west of the main pit is a shallow open-cut about 60 feet by 25 and about 10 to 15 feet deep. It has been opened into a little ridge of rock and is about 20 feet higher than the mouth of the main pit.

At this point there was a good chance to observe the mode of occurrence of the ore which in the notes taken on the spot is described as occurring in the basic country-rock as a veiney, often 'vuggy' mass

* See Nos. 17 and 18 Appendix A.



Autographed by Paul Frérault

of irregularly reticulated magnetite, with pink and cream-coloured calcite and black hornblende. The magnetite is plentifully intermixed through the rock in extensive irregular patches, and more intimately in veinlets and as scattered grains. Felspar patches are frequent and light-green epidote is a prominent feature. White quartz is also present although less frequent than the other minerals mentioned. The ore is frequently loose-textured from the presence of vuggy seams lined with crystals of hornblende, etc. Although at places the ore occurs in more solid masses with only a little admixture of the other minerals, over the main part of the rock surface exposed in this working, these other minerals together with rock inclusions will include 50 per cent of the mass. Robertsville and Mary Mines.

The foregoing description may be taken as applicable in a general sense to the other occurrences of ore at this place, and in other parts of the district with that class of deposits located in areas of compact basic rocks. Of course the different points opened up vary very much in the degree of concentration of the magnetite, that mineral at many places occurring in large concentrated masses yielding large quantities of very pure ore. It is evident, however, that such occurrences will be found in working, to be very variable and irregular. If, however, this feature is recognized and acted upon in dealing with them and prospecting work, both surface and underground, carried on systematically, in many instances it would doubtless be found that the number of ore-bodies would compensate for their irregularity. This constituted the noticeable feature in the phosphate mines of Ottawa county, Quebec, which worked for so many years successfully. In some of their pits the body of apatite would be worked out in a very short time, whilst in others a more or less abundant supply would be had for years.

Open-cut No. 3.—At this point a small open-cut has been driven east into the same ridge as the last mentioned, attaining a depth of 15 feet at its inner end. The rock seems to have a gneissic structure here and dips about 45 degrees south getting steeper as it goes down.

Pit No. 4.—Is a small test shaft, depth unknown. A rib of ore about 5 feet thick shows at the surface.

Pits 5 and 6.—Are just small prospect holes showing nothing in particular.

Open-cut No. 7.—This is in a side hill and is about 15 feet deep with a sinking in one end apparently only a few feet deeper. The ore occurs in dark basic rock similar to that at the other points, and shows the same reticulation of ore and associated minerals.

Robertsville and Mary Mines.

Open-cut No. 8.—Here a small open-cut into the side of a hill ends in a little tunnel about 125 feet long which turns in such a way as to pass under the working at No. 9, at a slight depth below the surface.

Open-cut No. 9.—Is a shallow open-cast working from which some ore has been taken, which at the time of the examination was piled near the opening.

Diamond Drill Exploration.—Besides the diamond drill holes described above, a number of others were put down on the hanging wall side of and at some distance from the range of ore-bodies along the strike, but no records are available as to results attained.

Shipments.—It is stated that between 6,000 and 7,000 tons of ore were shipped from this mine up to 1895, and according to the owner of the mine the ore shipped carried no sulphur.

Dip Needle Readings.—Six preliminary lines of dip needle readings at every ten paces were taken, but no particular attraction was shown except in the immediate vicinity of the main pit, and between pits 7 and 8, at the Mary mine openings.

Palmerston, XI, 27, 28

Palmerston Township, Con. XI., Lots 27, 28.

About a mile along the road west of Lavant station, on the Kingston and Pembroke railway, a little work has been done on an occurrence of magnetite. It consists of a small pit about 10 by 12 feet and, judging from the dump of rock, not very deep. It is at the base of a little limestone ridge, and the ore is at the contact of that rock with a gray gneiss.

The limestone shows at places, a contorted structure which is well brought out by the sinuous course of bands of magnetite of various thickness, and of other included minerals, among which actinolite and chlorite are of frequent occurrence. As noticed elsewhere this latter mineral seems to specially affect the limiting walls of the ore-ribs. The little ore-pile shows good ore, with some attached limestone and a little intermixture of chloritic and hornblendic minerals.

BYGROVE MINE.

Bygrove Mine.

South Sherbrooke Township, Con. I., Lot 3.

At this place little or no developments have been made. The work done consists of a pit about forty feet long by twenty feet wide. Its

depth, judging from the amount of the material extracted, and from information given by the residents of the vicinity, would be about twenty-five feet. It is full of water up to within ten feet of the top. Bygrove mine.

By careful chipping around the walls standing above the water-level, magnetite could be found in irregular, and apparently not very persistent ribs, varying from an inch or two, to a little over a foot in thickness, but they seemed often to thin out very rapidly in places, and to come in in other places in quite an eccentric manner.

Besides the pit mentioned, blasts have been put into the outcrop of the deposit, at several places, covering a length of about fifty feet. These workings have not been at all extensive, and show magnetite occurring in the same irregular way as in the pit.

As far as could be determined the strike is parallel to that of the distinctly banded gneissic rocks, seen to crop out to the southward, commencing about twenty feet from the pit. The work done is not of such a nature or extent as to enable a clear idea to be formed, as to the direction and extent of the outcrop, but if it continues to the west, it must be hidden by the cover of soil found in that direction, whilst to the east it does not show at all and the country rocks cropping out as they do also to the south, form apparently, a continuous bar to its extension in that direction.

A little to the north and east is a small rusty outcrop surface, like that of the rotten, rusty gneisses, so often found in this formation, which by assuming a turn in the strike, might have been taken to represent the deposit, but this would seem to be a somewhat doubtful assumption, as it evidently carries no magnetite and is all friable, breaking down under the pick. The rustiness here, as elsewhere, is probably due to the decomposition of pyrites contained in the rock.

In fact the continuance for any distance, of this local ore-bearing feature of the formation, seems very problematical, notwithstanding the theory started when the district was first being worked, that this occurrence was a continuation of the Fournier mine deposit, over four miles to the eastward.

Ore characteristics.—The ore taken out has been left in a pile near the pit, and probably represents the whole output, except a small experimental shipment of about six tons, said to have been made. The ore pile to-day would seem by measurement to contain about 140 tons, which agrees closely with the statement made in Mr. Vennor's report on this district (Report of Progress, 1870–72, p. 313). An examination

Bygrove mine.

of this pile showed it to consist largely of hornblende largely crystallized, but sometimes more finely with ribs and seams of magnetite through it. It is probable that the intermixed material would amount to fully fifty per cent of the whole. Pyrites is present but not in very large quantities.

Country rocks.—To the south of the pit for some distance there is a considerable development of gneiss of an acidic character. To the northward definite outcrops of solid rock are infrequent, there are, however, no signs of limestone for some distance at this point. The walls of the pit show a rather rotten brownish gneissic rock. The mineral character of the deposit could be best described as magnetite in irregular ribs and veins, or disseminated, associated with coarse, blackish-green hornblende, the latter crystallized in interferent aggregates, showing bright sparkling cleavage fracture surfaces. Occasionally vuggy places occur, lined with hornblende crystals.

FOURNIER MINE.

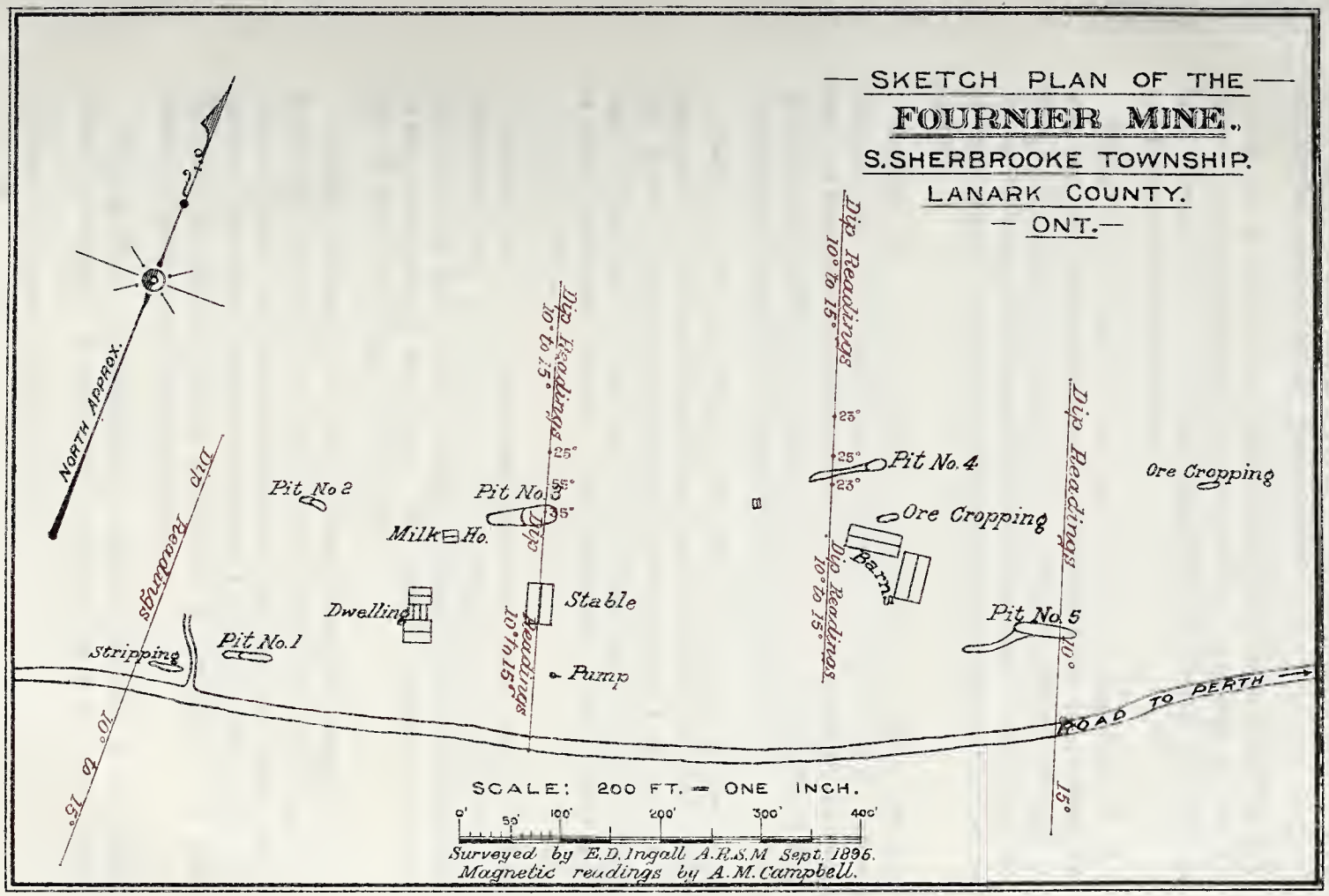
South Sherbrooke Township, Con. I, Lot 14.

Fournier mine.

The workings known by the above name consist of some five pits and other openings of various dimensions. The ore worked occurs in an area of basic rock which seems to consist largely of hornblende and augite with white felspar. Biotite is plentiful and pyrite seems to be fairly frequent in the various rock specimens collected. A banded arrangement of the constituents of the rock was noted at places, the bi-silicates alternating with whiter bands consisting of felspar and quartz. At places the rock would seem to consist of quite coarsely crystallized aggregate of biotite, hornblende, etc., constituting a dark basic rock, whilst lighter coloured acidic areas also occur, apparently consisting largely of felspar and quartz. The contact of these with the darker basic portions is not clear cut but is rather mergent. The ore occurs as irregular ribs and veins, and masses of a compact magnetite with a vitreous fracture. Where these occur in the basic portions of the rock, it frequently happens that the walls of the rib or vein are lined by large crystals of biotite, the crystallization of the basic rock also getting coarser and more hornblendic as it approaches the magnetite rib.*

From the accompanying plan it will be noticed that the pits and croppings seem to follow three parallel ranges having a general direc-

* See Appendix A, Specimens Nos. 8, 9 and 10.



Autographed by Paul Frérecuth

tion of about E.N.E. and W.S.W. This direction of the run of ore occurrences coincides roughly with that of the general formation of the district as shown on Mr. Vennor's map.* Fournier mine.

Pits Nos. 1 and 5 are on the most southerly range, pits Nos. 2, 3 and 4, on the most northerly, and the small ore croppings behind the barn, together with a similar one about 300 feet about E.N.E. seem to constitute an intermediate zone.

Whilst this is true, however, regarding the arrangement of the workings, etc., neither observation of the ground nor the result of the dip-needle readings so far as made favour the idea of the continuity of the ore between the different pits on the same range. The particulars of the different pits as far as could be observed on the surface are as follows:—

Working No. 1.—Is a shallow pit in the rock. A little ore was found in place at the west end, but it was so grown up with rushes that but little further could be seen. The small stripping to the west of this point consists of a shallow cut made by a few blasts on the outcropping of a small rib of magnetite, a few inches thick.

Working No. 2.—An irregular pit about 15 feet deep in the heavy basic rock. It is, however, so grown up with brush that but little can be seen. In the rock stripping at the west end of the pit a small isolated patch of ore occurs, exhibiting a surrounding envelope of dark hornblendic mineral. The hornblende of the rock shows at places, dark and coarsely crystallized.

Working No. 3.—Is a large open cut about 70 feet long by 20 feet wide with a deep pit at one end. According to our guide, this is about 120 feet deep and the ore-body was stated from his recollection to have been about 2 feet thick. Mr. Vennor's description of this mine in the Survey Report 1874-5 says:—

"During the summer of 1873, the last attempt at raising the ore for market was made, a shaft was sunk to a depth of 110 feet and the company raised in all about 600 tons of good ore. At this depth, however, the deposit becomes irregular and uncertain, and as the ore could not be extracted without the removal of much rock, work was abandoned and has not been resumed since."

Working No. 4.—This consists of a narrow open cut in the rock about 90 feet long. At its eastern end a pit has been sunk which

* Report of Progress, Geol. Surv. Can., 1874-5.

Fournier mine.

according to our guide went down perpendicularly for about 40 feet and showed about 8 feet thick of ore all the way down. At the mouth of this pit several ribs of ore are visible measuring from 1 inch to 6 or 8 inches thick, the magnetite itself, where it shows, appearing pure.

Working No. 5.—Is a shallow open-cut in the rock about 5 feet deep and about 60 feet long with a surface stripping for another 50 feet south-west from it. Several small ribs of ore are visible as at the other pits.

Other Outcroppings.—Other points where ore occurs are shown on the accompanying plan close behind the barns and 300 yards about W.N.W. from the same. Only small ribs of ore are however visible.

Dip Needle Readings.—Readings were taken at intervals of about ten paces apart along four lines and results have been inscribed on the plan. It will be noted that the average attraction of the district was only disturbed in the immediate vicinity of the pits, or at these points where ore was already known to occur and had been worked.

Ore Characteristics.—All the ore mined during the operations carried on in previous years having been removed, there was no opportunity to judge its characteristics. From its mode of occurrence, however, and from what little was lying around, it is evident that the intermixture of foreign material would mainly consist of hornblende, pyroxene and mica.

Mr. Vennor in his report states that the ore is free from titanium and this would seem to be borne out by the analysis of the specimen collected personally, which is given in the tabulation at the end of this report. The remarks upon the proper interpretation of assay results given in the Introduction must however be borne in mind.

ALLAWS MINE.

North Crosby Township, Con. IV., Lot 27.

Allaws mine.

Time allowed of but a hurried visit to this place. According to our guide, Mr. Fournier, who resides on the next lot north of this, the points visited comprised all the work done on the deposit.

These consisted of a couple of shallow strippings, about 25 by 40 feet and about 50 feet apart. The surface rock had been blasted away for a few feet down from the surface. The surrounding rock is a dark basic variety apparently very similar to that of the Fournier mine

above described showing at places magnetite in small ribs and veins, etc. Allans mine.

The work was in such a condition that but little could be determined as to the important features of the deposit.

Our guide, who worked at the mine when it was in operation, stated that no ore was shipped. Nothing could be seen representing ore extracted, except some small piles which would represent in all about 20 tons of material. If these were set aside as ore, the grade would be low from the very large admixture of rock material. As however Mr. Vennor's description of this place speaks of 100 tons of ore as having been raised, either the good portion of that extracted must have been shipped away, or some other excavations must exist which were not seen.

An analysis of a specimen of this ore was made by Dr. Sterry Hunt and will be found in the tabulated assays at the end of the report. It shows the mineral to be low in phosphorus but somewhat high in sulphur and titanium.

CHRISTIES LAKE MINE.

South Sherbrooke Township, Con. III., Lot 18, 19 and 20.

The workings going by this name are situated on the shore of Christies lake at a distance of about twelve miles W.S.W. from the town of Perth. The examinations made were of the workings on lot 18. They are situated on the steep slope of the north shore of Christies lake and the distribution of the different pits is shown in the accompanying sketch plan. Christies Lake mine.

Working No. 1.—Is an open cut run for a length of about 100 feet northerly into the base of the hill close to the shore and a little above the level of the lake. The floor of the cut is only level for a short distance after which a step about fifteen feet high is encountered, beyond which the floor of the cut rises at an angle of about thirty degrees, following approximately the slope of the formation at this point. This consists of rusty gneissic rock, in which is an ore rib which dips with the rock. Underlying the ore rib is basic gneiss, and lying immediately on top of it, is a salmon coloured, more felspathic member of the series. The basic gneiss crops out beyond, forming the top of the hill being so found as far as followed for a distance further north of about 200 yards.

Christies Lake mine.

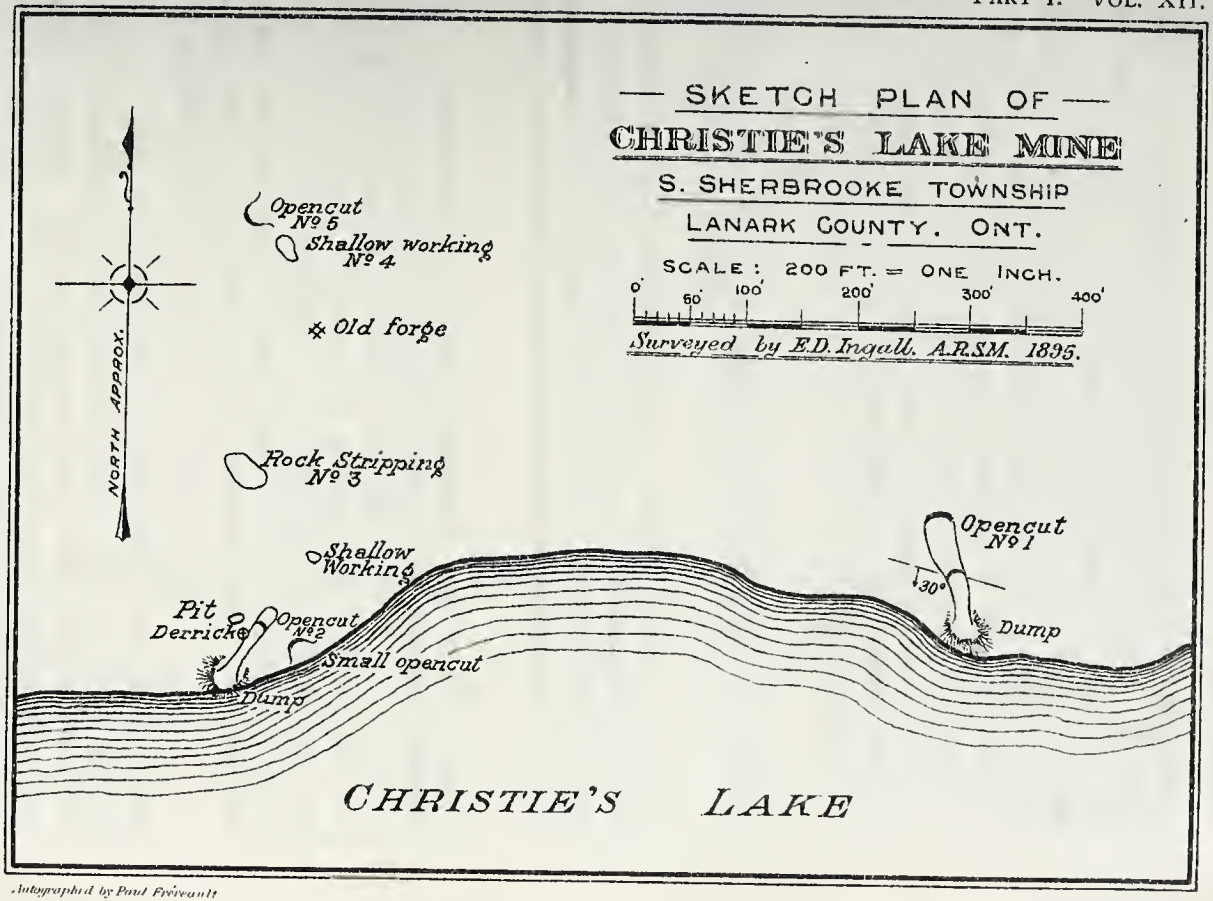
The rocky walls of the working being very much stained with rust a careful examination was made with the pick along the length of the cut where the orey rib was found to have a thickness of but a few inches at the lower end towards the lake, increasing to about four feet at the upper end of the working. This is evidently the place spoken of by Mr. Vennor in his description of these mines in the 'Report of Progress of the Geological Survey, 1872–3, pp. 174–5.' He there says: 'the uppermost lead of ore and the nearest to the lake has been uncovered for about thirty-five feet in length by twenty-four feet in breadth and a considerable mass of ore has been exposed. No walls have yet been reached and I think it is probable that the uncovering has been extended on the face of the bed, rather than across the outcrop.'

It is evident that much work was done subsequent to his observations and that his surmise was correct, the hanging wall rock having been simply stripped off, exposing a certain amount of the back of the ore rib. When this was pierced, however, and its comparative thickness demonstrated, the erroneous conclusions of the miners as to the extent of the ore-body based on the large exposed surface of ore, must have been dispelled. Judging from the general rustiness pyrite is probably present in quantity.

Working No. 2.—About 600 feet further west along the shore, from the last mentioned, is another open cut into the rocky slope of the lake shore. Starting a short distance from the water's edge and slightly above that level, it has been run inward for about seventy-five feet in a north-easterly direction ending in a face about ten to fifteen feet in height. The rock passed through reminded one strongly of the harder and darker coloured pyroxenites of the phosphate district of Ottawa county, Quebec.* Here, as there, irregular centers or vuggs occur frequently which are lined with crystals of the rock constituents and throughout the exposure, pink and cream coloured calcite shows in irregular patches and veinlets. As with the phosphate, magnetite occurs irregularly throughout the mass, being perhaps more particularly found in connection with the loose, vuggy portions. At one place a vugg was noticed lined with fairly well-defined crystals of magnetite. Pyrite is also frequent at times in patches of considerable extent and pale green apatite was also observed. All these minerals seem to be more distinctly separated out where free crystallization has been possible.

The resemblance to the phosphate formation already noted is rendered more complete, by the presence here also of the curious

* See Appendix A., specimen No. 5.



Autographed by Paul Frérault

so-called 'leopard rock' so frequently found in connection with the apatite deposits. Close to the northern end of this open cut and on the western side a pit of small diameter has been sunk to a depth of about 15 feet and at short distances around are several shallow prospecting pits. Christies Lake mine.

Working No. 3.—About 125 feet north of the inner end of the open cut just described, is a shallow rock stripping the centre of which shows a surface about 40 by 20 feet of pretty good orey ground. The surrounding rock surfaces are very rusty and rotten, and pyrite seems to be plentiful. Owing to this, and to the way the opening has been made, determination of the essential features of the ore body are rendered difficult. It looks, however, as if it represented an approximately flat lying ore-body from which the overlying rock had been stripped. Thus the exposure of ore surface made, would give no measure of the real extent of the ore-body, its thickness, strike or dip, etc.

Working No. 4.—Is a shallow open cut working in ore the occurrence of which however is irregular.

Working No. 5.—Is an open cut run southerly into the rise of the hill, and having a face of about 10 by 12 feet. There seems to be a good deal of ore in ribs right across, but as elsewhere, the workings are not in condition to give any definite data as to the mode of occurrence.

Dip Needle observations.—Time permitted of but two main lines of readings being taken, which for convenience of reference are designated A. and B. The first (A) beginning on the shore of the lake at the mouth of open cut No. 1, passing up through the open cut was continued in a northerly direction, the whole distance measuring about 600 feet. For the first 200 feet in the proximity of the working considerable disturbance of the needle is recorded, but for the last 400 feet practically no abnormal attraction was noticed.

The second line (B) commenced at the shore at the mouth of open cut No. 2, proceeding in a direction about N.E. for about 150 feet alongside the cut. The readings were then continued about northerly to No. 4 working, for some 300 feet, and thence north-westerly past workings 4 and 5 for about 100 feet. The only noticeable disturbances of the needle were shown along the first 150 feet in the vicinity of No. 1 open cut and adjacent workings. For the remainder of the distance no local attraction was shown.

Christies Lake mine.

Besides the above, investigation was made for local attraction at a number of other points. Readings were taken every few feet along the lower and outer bench of open cut No. 1, as well as along the length of open cut No. 2, no attraction being found in either case. Readings of the needle were made every few paces from working No. 2 to working No. 3, and all around these workings thence southward to the shore of the lake every few paces, but no attraction was shown except at one point near the S.W. edge of the stripping. Around the workings Nos 4 and 5 no attraction was found except where the needle was held close to the small ribs of ore showing.

General Observations.—At this mine the ore where exposed all occurs in the gneissic rocks. Limestone however probably occupies the floor of the lake near the shore as the general strike of the formation in this vicinity being about N.E. and S.W. would locate there the continuation of the band of that rock, which shows on the lake shore about a mile eastward of the mine. This supposition is borne out by the occurrence of a large island of limestone almost immediately in front of the workings about a quarter of a mile out from the shore. About 200 feet west of open cut No. 2, limestone occupies the shore line for a distance of about 200 feet, but does not appear to pass inland and is probably just a fringe of the main band already alluded to.

The unsatisfactory way in which the development work has been done, the second growth bush, and the general conditions, render it very difficult to decide upon the relationships of the different exposures to each other. It is further hard to make the workings above described coincide with the description given by Mr. Vennor in the report of progress of the Geological Survey for 1872-73. The first mentioned opening of his description seems to tally with open cut No. 1 above described, but beyond that I was not able to follow the description on the ground. This may have been on account of work done subsequent to his visit.

Judging, however, from all the features presented at the various points where ore is exposed, as far as those visited are concerned, the mode of occurrence would seem to be more likely to be as elsewhere in the district, viz., irregular deposits in basic gneissic rocks, rather than that these should be interpreted as they were formerly as points on the outcropping of several continuous beds of ore underlying each other. The dip needle results also as far as they went would seem to weigh against the latter probability

The two open cuts on the shore were connected and surveyed in with plane table and micrometer, but the inland workings had to be sketched by means of compass and pacing.

Mr. Vennor's description before alluded to, gives also an analysis of a specimen of the ore by Dr. Harrington, then chemist to the Geological Survey*. From this it is evident that the ore at this place resembles that at the Chaffy mine in being more or less titaniferous. The percentage of phosphorus would probably depend upon the care with which apatite was looked for and sorted out when it was found to occur in places in the deposit. Christies Lake mine

South Shore Workings.—Mr. Vennor mentions some work which was done on the south shore of the lake about opposite those above described. The ore is said to have been of good quality, but does not appear to have occurred in quantity and the work done was not extensive.

SILVER LAKE MINE.

South Sherbrooke Township, Con. IV., Lot 16.

A visit was made to some workings about a mile W. from the Christie's Lake mine. These were situated on the east shore of Silver lake. Mr. Vennor in his report to the survey mentions some more extensive workings as occurring on the south side of the lake on lots 13, 14 and 15 in the same range. Notwithstanding that, our guide showed those on 16 as constituting the Silver Lake mine, the two places are evidently distinct. Silver Lake mine.

At the place visited a small cut (A) about 30 by 20 feet had been opened out in the side hill rising from the shore of the lake. The working is near the water's edge and its face rises about 12 feet above the level of the same.

This opening has been made in a dark compact hornblendic rock. An examination of the walls extending around the sides of the workings showed only very little magnetite, as if the whole body had been taken out leaving a little of the mineral attached at a few places around the edge. In judging the material which has come out of the opening and assuming that the more carefully made pile is the ore, it would seem that the latter represents but a more magnetiferous portion of the basic rock in which the excavation has been made. But little pyrite was noted.

About 100 yards in a southerly direction on the shore of the lake is an exposure of dark crystalline hornblende, reticulated with ribs and veins of magnetite, and showing occasional irregular areas of the

* See table of analyses, Appendix B.

Silver Lake mine.

'leopard rock' before alluded to as occurring at Christie's Lake mine. Between these two points are several insignificant shallow workings in the hornblendic rock.

On the south-west side of these basic rocks a coarse crystalline limestone outcrops skirting along the shore. It shows numerous and curious inclusions of the dark basic rock, which are often twisted and frequently have a corroded surface. At a point a few rods northerly from the main working a forked tongue of the crystalline limestone penetrates the dark basic rock.

Dip Needle Readings.—A line of readings with the dip needle was taken in a north-west and south-east direction between the southerly exposure on the shore and the main pit, and continued beyond that point for about 200 feet and a line also at right angles to this crossing the main pit, extending about 250 feet from the lake shore. South of the large pit the attraction appears to be strong on the average, with some evidences at one or two intermediate points of possible occurrences of magnetite. To the north of this pit no attraction out of the normal was found to exist.

Along the line crossing the large working in an easterly and westerly direction from the shore inland for some 250 feet, but little disturbance of the needle was shown.

The next described form a range of mineral properties on a line running roughly E N.E and W.S.W. upon which have been made a few openings on small bodies of magnetite. The particulars noted at each place are as follows :—

RITCHIE MINE.

South Sherbrooke Township, Con. VII., Lot 16.

Ritchie mine.

At this point a small test pit had been sunk to the depth of about 10 feet, in which were visible two exposures of magnetite, one on the south side, and the other on the north side of the pit. These ore ribs for the few feet exposed, seem to follow in a general way, along the strike of the inclosing gneissic rock which is about east and west. The dip seems to be to the south 40° on the north side, and about 60° on the south side.

The section exposed in the east end of the pit, shows the two ore ribs separated by pale pink felspathic gneissic rock a few feet in thickness, in which the structure is marked by thin streaks and bands of a

dark mineral probably hornblende. Judging from the trend of these, there is here a small overturned synclinal bend in the gneiss, and the two ore-exposures are probably portions of a single rib following the same bend. At the west end of the pit the ore-rib seems to thin out very considerably. Ritchie mine.

A number of vugs or cavities occur both in the ore-ribs and at the bend in the rock between them, and these cavities are lined with well formed hornblende crystals. An irregular development of calcite at the west end of the pit seems also to be part of the ore-formation. A little mica seems to be associated with the ore in the calcite portion of the deposit, and the magnetite sometimes occurs in rounded nodules in the vein in a granular matrix of mixed magnetite and hornblende. The inclosing rock seems to be a somewhat basic gneiss.*

In the pit above described the ore occurs associated with a more acidic variety in which the heavier minerals, hornblende, etc., are represented only by the dark streaks and lines of crystals marking the parallel structure of the rock.* A little distance to the south of the pit, however, the proportion of hornblende, etc., is much larger giving a darker and more basic gneiss.†

About 100 feet south of the above described ore occurrence, a similar ore exposure shows lying about parallel with the same. It is about 2 feet thick and showing for a length of about 6 feet. Between the two is a cropping of a narrow band of crystalline calcite similar to that showing in the pit.

The ore consists sometimes of a coarse granular aggregate of magnetite sometimes of that mineral in more compact masses showing a vitreous fracture.

MORROW MINE.

South Sherbrooke Township, Con. VIII., Lot 13.

About a mile W.S.W. from the last described, is the property known as the Morrow Mine. A small pit about 15 feet in diameter by about 10 feet deep, has been sunk on what appears to have been a small pocket of magnetite in the basic gneiss of the vicinity. The rock here as at the Ritchie Mine strikes about east and west. Morrow mine.

The magnetite occurs sometimes massive with a vitreous fracture, sometimes with a loose pebbly structure like an interferent aggregate

See Appendix A: *Specimens 16 & 16 b, c & d. † Idem Specimen 16a.

Morrow mine. of crystals, the grains being at times roughly octahedral in form, and again as a mass of magnetite and quartz. A little admixture of mica shows in the ore pile and apatite is to be recognized not infrequently. A good deal of rust is present from the decomposition of the pyrite, which judging from the waste dump appears to have occurred plentifully and in large pieces in the deposit, which was evidently characterised by the presence of vugs and cavities lined with quartz and crystals of black hornblende.

MABERLY PROPERTIES.

Maberly properties. An extension of the ore-bearing belt, in which the two last described properties are situated is claimed as having been proved for about five miles to the W.S.W.

This belief of the owners of the properties seems to be based upon the evidence of the dip-needle, as no development work has been done. A day was spent in making a partial examination of this range of country with the dip-needle, but it is evident that no very definite conclusions could be arrived at by any one without making a complete and systematic magnetic survey.

Commencing at lot 15, Con. V., Oso Tp., considerable attraction was shown at a number of points along a distance of about three miles to about lot 9, Con. IX. in South Sherbrooke. Whilst, however, these heavy dips were shown at isolated points, the attraction between these points was found to be light. In fact, failing more complete observation with the needle the evidence so far adduced would lead rather to the belief in the existence of a basic belt of gneiss carrying probably a fair proportion of magnetite as one of the constituents of the rock, that mineral being more concentrated at spots. At these points when located by a systematic magnetic survey, development work might prove the existence of aggregations of the magnetite into bodies of sufficient purity and extent, to be profitably worked. The rock croppings observed along the distance traversed corroborated this view, consisting as they did of a basic hornblendic gneiss, very similar to that described in connection with the Morrow and Ritchie properties. On lot 15, con. V., Oso Tp., this rock was found at places to show a considerable proportion of disseminated magnetite and some pieces of pure ore were also obtained.

FARREL'S LOT.

Bathurst Township.

Farrels lot.

On the road between the Fournier mine and the east end of Christie's Lake on the lot of Mr. George Farrel an interesting occurrence of magnetite was visited.

The mineral occurs in a little outcropping of crystalline limestone or calcitic rock, in a pasture. All around appeared the basic gneissic rock so common in the district, in such a way as to seem to quite surround the limestone which is cut at this point by a coarse pegmatite dyke. The magnetite occurs as isolated nodules throughout the limestone, and as protuberances from the walls of the waterworn channels and little caves that traverse it. These were the only features noticeable in the very short time at disposal for the examination, but it is worthy of record as a curious association in which to find the mineral. It would require a much longer time and closer study to throw light on the mode of origin of the magnetite at this place.

FOLEY MINE.

Con. VIII., Lots 10 and 11, Bathurst Township.

Foley mine.

The workings that went by this name are situated about eight miles west of Perth. The existence of magnetite deposits at this place was mentioned by Mr. Vennor, in the Report of Progress of the Geological Survey for 1870–71. He also drew attention to the frequent admixture of crystalline green apatite with the ore, the presence of which mineral was also noted during my examination. A number of openings have been made on lot 11, toward its southern end. One was 10 feet deep, another being full of water, its depth could not be ascertained, and all the openings were small. The ore occurs in what seems to be a dark basic rock which crops out all around and is apparently for the most part compact in structure although at places there is some semblance of parallel structure. At places mica and hornblende occur in large crystals.

In examining the pits by chipping all round, no evidence could be found of any extension of the different ore-bodies, but as far as could be ascertained they were circumscribed by the inclosing rock. This was clearly the case in one pit.

Foley mine.

No limestone shows in the immediate vicinity, and its mode of occurrence strongly recalls, as mentioned in other cases, that of the apatite in Ottawa County, Quebec, viz.: irregular aggregations of the mineral throughout an area of basic rock. The peculiarly compact structure of the magnetite and its very vitreous fracture is in marked contrast with the duller lustre and granular or cemented granular structure, chiefly affected by the contact deposits of the district.

On lot 10 very similar conditions were observed. The developments made consist of three pits on a northerly and southerly line and rather more extensive than those on the last mentioned lot. They cover a distance estimated at about 150 yards. The ore having been practically all removed it was impossible to determine the presence or absence of apatite or pyrite. None was found however in what little mineral was yet found scattered around.

The pits are irregular test shafts the most southerly one showing a depth of about 25 feet above the water, and the most northerly one about 15 feet. The latter had been worked by means of a derrick. The middle pit was too much caved in to enable much to be observed, but the rock around seemed to be all similar to that already described.

At places in the vicinity, a coarse granitic structured rock outcrops apparently pegmatite. As far as could be ascertained in a short and hurried examination and with so small an amount of development made, the impression left was that of coarsely aggregated pockets of magnetite with hornblende, apatite and pyrite, in an area of diorite.

In his evidence before the Ontario Mineral Commission, 1889, Mr. Bawden states that two car loads of good ore was taken out from work done on lot 12, and that twenty years previously, some ore from this point was shipped to Cleveland, Ohio, where it was tested and reported upon favourably

WILBUR MINE.

Lavant Township, Con. XII., Lots 3 and 4—Con. XIII., Lots 3 and 4.

Wilbur mine.

The chief pits at this mine are situated on lot 4, in Con. XII., the workings also crossing the S.E. corner of Lot 4 in Con. XIII., and the N.E. corner of lot 4 in Con. XIII. A siding about a mile in length, connects the workings with the Kingston & Pembroke Railway.

The most easterly workings are situated upon a hill which slopes northward down to a beaver swamp. Passing westward along the

WILBUR MINE
LAVANT TOWNSHIP
ANARK COUNTY
ONT
SWAMP
LIMESTONE
BETWEEN
GNEISS
SWAMP
GNEISS
LOT LINE
LEGEND
Barn
Shaft
Pit
Drill
Workings
Engine House
Dump
Road to Lavant

line of pits, the edge of the ridge is passed over, so that the most westerly pits lie at its base, and are therefore much lower than the last mentioned. The line of pits is curved, but the strike of the chain of ore-bodies would average about N.E. The dip of the formation and of the workings on the ore varies from 25 degrees to 40 degrees in a southerly direction, which, taken with the rise of the hill, partly accounts for the curve in the line of pits. At the east end, however, there seems to be evidences of contortion of the formation but the relationship of the worked ore-bodies to each other, and to the inclosing rocks, is somewhat confused, and the time at disposal did not allow of sufficiently detailed work to decide these points. The accompanying plan shows the detail of the workings. Wilbur min

Commencing at the foot of the hill and working eastwards up the slope, the description of the different pits is as follows :—

The workings numbered 1, 2, 3, 4 and 5 are all in the gneiss or close to its contact with the underlying limestone.

Working No. 1.—Consists of a shallow pit abandoned a long time previous to the examination.

Working No. 2.—Here an incline has been sunk at a point where some shallow surface pits had been previously made. At the time of examination, however, nothing could be seen, the excavation being full of water.

Working No. 3.—At this place is an open cut about 160 feet along the outcrop of the ore-body, the incline shaft shown on the plan having been sunk below its western end. Work was progressing at the time of the visit made, so that some features of the deposit could be seen. In inaugurating the present operations, the old workings were unwatered, and drifting was done to connect the old or westerly incline (3*a*) with the new incline (3*b*) sunk to the east of the same, as shown on the plan. Connection was also made with the old excavation below working No. 4.

The old shaft (No. 3*a*) is inclined at about 30 degrees down to the first drift, after which the excavation is continued on the level to the end. All the drifts shown are on this level, the incline (No. 3*b*) in its downward continuation, passing below them at an average angle of inclination of about 14 degrees. The formation flattened out in depth, the inclination of the upper part being about 27 degrees, whilst below it flattens off in places to as little as 8 to 10 degrees.* Numerous long

* According to the latest information received. January 1901 this incline had attained a depth of over 330 feet.

Wilbur mine.

holes have been put in with the steam drill at various points for the purpose of testing the thickness of the ore-body at various points in the workings.

Working No. 4.—This, at surface is also an open pit of irregular shape and dimensions, extending some 180 feet along the outcropping of the ore-body. Here as at No. 3 the ore occurs in the gneissic rock close to its contact with the underlying limestone. The underground features at this point could not be studied, descent being prevented by debris at the mouth of the pit, and water filling the excavation in depth. At the surface the dip seemed to be about 30 to 40 degrees to the south-east. The workings at this point are said to have extended to a depth of about 250 feet.

Working No. 6.—Is sunk vertically at the base of a small boss of the gneissic rock which is well shown also in the adjacent rock-cut through which the track passes. Here also owing to the water, only surface features can be noted. It is said however that several bands of ore were passed through. On the east side is a wall or 'slip' dipping steeply about north-east, which may be a fault plane in the formation, and partly account for the irregularities already noted as existing east from this point.

Working No. 7.—The next development of importance is situated on top of the hill, and judging from the size of the waste dumps must have been extensive. The pit is, of course, full of water, but as the walls of the excavation rise some ten to twenty feet above its surface, somewhat can be judged of the conditions under which the ore-body exists. This pit is stated to have been sunk to a depth of about 300 feet on the incline. The dimensions of the ore-body seem to have been irregular and it is stated to have varied from but a slight thickness to sixty feet in thickness.

At this point the strike of the rocks would seem to indicate a local turn or twist in the formation, and the dip of the ore-body as followed down in the workings, would be at an angle of about 30 degrees north-east, as contrasted with the Easterly dip shown in the western workings. This interpretation of the phenomena must however be taken as provisional only, as most of the data necessary to corroborate it are lacking. Had time permitted when the examination was made, more dips and strikes might have been observed, and with these and the details of the underground work, it might have been possible to arrive at some reliable conclusions. For the same reason the exact distribution of the rocks, as shown on the plan, is subject to correction, but the lines drawn are such as the data at command would seem to

indicate. The eastern limitation of the gneiss-covered area, together with the detached portion of the same, lying between No. 7 and No. 8, would seem to owe their position to the removal of the overlying gneissic rock in the low ground between No. 6 and No. 8 by denudation, but as most of this area is swampy, and rock exposures are therefore scarce, this also is partly conjectural. Wilbur mine.

Working No. 8.—These pits were so full of water, and the inclosing rocks, so obscured with cover, that there was little to note regarding them. Considerable work seems to have been done however.

Working No. 5.—In the distance between the pits Nos. 3 and 4 and those at the western end of the property, there are a few unimportant workings (No. 5). They consist of a little tunnel, run in just below the brow of the ridge, at a very slight depth below the surface; of a little opencast working, and a couple of small test shafts as shown. Nothing of importance seems to have been developed there. These excavations all seem to be in the lower part of the gneissic rocks overlying the limestone.

Diamond Drill Explorations.—The diamond drill has been used to a considerable extent at this mine, and the position of some twenty-seven holes are marked on the plan.

The fifteen holes lettered 'K' to 'Y' were put down some years since during the early days of mining at this place and only fragmentary information exists in regard to them. As far as can be learned many of these were quite shallow. Of the longer holes, the deepest was 350 feet. Of the five of which any record is available and which pierced the ore formation, the ore passed through is reported to have varied in thickness from 3 to 28 feet. It is regrettable that no records are available, as without these and the cores it is impossible to properly interpret even the data available and much is lost which might have helped materially in unravelling the geological structure and the relationship, distribution and dimensions of the ore-bodies.

The holes numbered 1 to 12 have been put down recently to varying depths of from 60 to 175 feet. The records of these are not available for publication, but it is stated that ore was encountered in all except one, ranging in thickness from 5 to 15 feet. The widespread distribution of ore is thus shown and the thicknesses of the ore-bodies are in a measure given as these western holes were all sunk at right angles to the general dip of the ore zone. In the case of irregular deposits however, such as exist in this district, the indications of the drill, whilst invaluable as a guide, must be used with judgment, as in the

Wilbur mine.

nature of things, considerable changes in thickness, etc., are apt to occur in quite short distances.*

Magnetic readings.—The magnetic curves shown on the plan, give the results of the observations made with the dial compass and dip needle. They are unfortunately rather few in number for the purpose, on account of the limited time at disposal. Although no detailed conclusions can be drawn from them, they illustrate, however, certain general features. In speaking of them they will be referred to in their order, numbering from the east.

It will be seen that along the chain of ore-bodies from workings Nos. 5 to 8, the zone of magnetic disturbance coincides with the known distribution of the ore-bodies, and, in some cases, as with line 6, gives evidence of ore where no openings have been made. Along line 1 there appears little or no evidence of magnetic material. Lines 7, 8, 9 and 10, would seem to indicate an absence of any considerable ore-bodies near the surface, in the distance between the eastern and western groups of pits. Along lines 11 to 16 we have again a zone of magnetic disturbance coinciding with the run of the ore-bodies near their outcropping, as well as some indication of ore, at the southern end of the last mentioned line. At this point the rise in the ground and the dip of the formation would probably remove the needles from the influence of the ore zone which outcrops at the pits, so that the attraction shown may be due either to another ore-body lying higher in the formation or to a higher position of the original one due to faulting.

In order to arrive at more detailed conclusions, it would undoubtedly be necessary, to take magnetic cross-sections as close as every 20 or 25 feet, but the preliminary lines run, bring out the broader features. In studying these, the following points must be borne in mind. The cessation of magnetic disturbance in passing south, is by no means to be attributed to the termination of ore in depth, as the southerly dip of the formation and the rise in the surface of the ground, would soon remove the instruments out of the range of influence of the deeper parts of the ore-bodies. The continuation of the lines for a distance on the hanging wall sides serves the purpose of exploring for any possible bodies higher up in the formation and similarly their extension north serves to demonstrate the presence or absence, in the limestone belt, of the footwall side, of other deposits, which being either covered or not coming quite to the rock surface, might yet demonstrate their presence by their influence on the magnetic needle.

* An instance of this is recorded in a letter recently received from the owner wherein he states that the underground development had gone through 27 feet of solid ore in the vicinity of a hole which had only passed through about half the thickness

General Observations.—From the study of the general features on the surface and those brought out in the developments made, it would seem that the magnetite occurs as a series of detached ore-bodies in the gneissic rocks at their contact with the underlying limestone. This contact is fairly sharply defined at places, as shown in the western workings but, in the vicinity of the eastern pits, the two series of rocks seem to be separated by an alteration zone of greater or less thickness. In this are to be found chlorite, epidote, etc., evidently the products of decomposition of the mineral constituents of the gneiss. Judging from the dumps at pits Nos. 6 and 7 the ore must have been associated with large quantities of chloritic schistose material probably forming an envelope for the same, as it was seen to do elsewhere in the district. The drill holes Nos. 8, 9 and 10 passed through much of this kind of material and frequently for many feet the cores were composed entirely of epidote. Several ribs of unaltered gneiss were also pierced, alternating with highly chloritic and talcose limestone, before the solid limestone was encountered. Wilbur mine.

In the cores examined from the western drill holes the same features were noted only in a less degree. The break between the overlying gneissic rocks and the limestone below seemed to be sharper, although here also detached ribs of gneissic rock were passed through in the limestone below the main body of gneiss above.

All the workings are practically in the gneiss, or in the altered basal portions of the same. From the microscopic examination of one section from a specimen of the overlying rock it has been called a biotite-granite-gneiss*, although of course, microscopic determination of specimens from other parts of the area would probably show variations from this type.

The limestone band shows a great many interesting features. Irregular wavy ribs and seams of white quartz are a common feature and in places occur in such large proportion as to constitute the rock almost a calcareous quartzite rather than a quartzose limestone. This is a common feature even at points quite removed from the contact with the gneiss. Inclusions with the appearance of having been originally gneissic matter, but now more or less completely altered into chlorite, etc., are common, and thay all conform in general direction with the banding and strike of the limestone. This rock is white in colour and frequently exhibits all the characteristics of a marble.

* See Appendix A, Specimen No. 19.

Wilbur mine.

History and Shipments.—This mine was first opened many years ago, and worked at one time for several years under lease by the Kingston and Pembroke Mining Co. It is now being developed by its owner, Mr. Wm. Caldwell, of Toronto, Ont., the leases having lapsed. He has installed a plant with the intention of proving the extension of the ore-bodies in depth, etc. The chief work is being done at pit No. 3, where a small compressor plant for air drills together with a hoisting engine and the necessary blacksmith, repair, and other shops, have been erected. Considerable work was in progress with the diamond drill also, both in this vicinity and as previously stated, at the eastern end of the property also. It is said that during the previous periods of working, some 125,000 tons of ore of a high grade were shipped.

Characteristics of Ore.—Near the lower pits, Nos. 3 and 4, a large pile of ore was stacked, at the time of the first visit made. It measured about 1,000 tons. This was carefully looked over with the result that little or no pyrites was visible. The ore showed a parallel structure, and was seamed throughout with chlorite and calcite, the latter minerals by eye estimate constituting about 10 to 15 per cent of the whole. A small vein of pyrite 6 to 7 inches thick, is said to have occurred along the foot wall in one part of the mine, but it was quite distinct from the ore which could therefore be kept free from contamination with this deleterious ingredient.

RADENHURST AND CALDWELL MINES.

Radenhurst and Caldwell mines.

Lavant Township, Con. III., W 1-2 Lot 22. Con. IV., E 1-2 Lot 22.

These properties are situated near Flower station on the Kingston and Pembroke railway, and in case of their being re-worked, would thus be quite convenient to a shipping point. In the short time available it was found possible to make but a general examination of the area, during which the following facts were ascertained.

The developments consist of a number of pits and strippings spread over a distance of about 1,500 feet on a general run E.N.E. and W.S.W. which seems to be the average strike of the formation in this vicinity. The rocks consist of rusty schists and gneisses of various compositions. As usual, the rustiness seems to be due to the presence of a large percentage of pyrite, which by its weathering, stains the rock with the residual oxide of iron. No limestone is visible in the immediate vicinity of the workings.

Working No. 1.—Beginning at the eastern end of this range of openings we found a pit about thirty feet square, and said to be about thirty feet deep. It is in the rusty, schistose rocks, which here dip about 70 degrees south. The pit was full of water, but small ribs of magnetite show on the surface. Radenhurst and Caldwell mines.

There seems to be some tendency toward a veiny structure at this point, actinolite, quartz, calcite and other minerals, occurring in a veiny way. The magnetic attraction near the pit is quite strong, the north end of the needle pointing nearly south.

Working No. 2.—Proceeding west about 150 paces two pits close to each other are encountered, which are said to be about eighty feet deep. They are pretty well filled up with debris from the running in of the sides, so that nothing could be here ascertained as to the nature of the deposit, except what can be gleaned from an examination of the dumps. These show a very mixed lot of rock, chiefly chloritic material, with parallel seams and ribs of magnetite, and a small percentage of lumps of pretty good ore.

Working No. 3.—About thirty paces south from the last is a pit said to be about twenty feet deep. It is in schistose rocks which here strike about N.E. and dip about sixty degrees south. Judging from the material in the dump there seem to have been little ribs of magnetite in places, running with the strike of the rock.

Working No. 4.—About 150 paces further west again, is another shaft, said to be 108 feet deep, with a drift to the east about twenty feet in length. It is cribbed and lined, and was full of water nearly to the top when examined. The outcropping around the excavation, however, could be examined and the strike of the rock would seem to be a little north of east with a dip of about seventy degrees south. The magnetite seems to occur as elsewhere in ribs and veins, cutting rusty schistose rocks. At this point is an ore-pile measuring about 600 tons.

Working No. 5.—About 250 feet west from the last is a stripping measuring about twelve by twenty-five paces. The whole width shows a rusty schistose rock with ribs of magnetite.

Working No. 6.—At a distance of possibly 500 feet west from the last mentioned, and on the Caldwell property, are two little pits within about fifty feet of each other. One of these near the engine house is said to be about ninety feet deep, and near it a diamond drill hole has been put down, apparently with the dip of the rocks, said to be about 200 feet in depth. Both these points show at surface a rusty

Radenhurst and Caldwell mines.

belt of gneiss or schist, about twenty feet wide, impregnated along some bands with magnetite either as plentiful grains intermixed with the other constituents of the rock, or as solid ribs constituting the best ore.

Judging from the general rustiness of the belt running through all these points, and from the evidence of the ore piles, pyrites must be plentiful at place.

YUILL MINE.

Darling Township, Con. V., East half of Lot 25.

Yuill mine.

On this lot a large open pit has been sunk in a body of magnetite. The work was done in 1889-90. At the time of our visit it was partly full of water, the surface of which was about 30 feet from the highest point of the surrounding rock. The pit is about 90 feet in length, about 30 feet wide at its wider end and about 15 feet at its narrower. On the north side is a dark compact, basic rock, the microscopic determination of the inclusions of the same found in the ore showing it to be diorite.† On the south and west the ore body is bounded by limestone. At the narrow eastern end of the pit, the cover and bush prevent the features of the rocks being made out.

The basic rock of the north side is very compact and structureless, except for some little schistose seams running off into it from the pit. Veinlets of white quartz are of very occasional occurrence in both the basic and calcareous inclosing rocks. The limestone shows signs of being much contorted in places and is of a more marbly texture than usual.

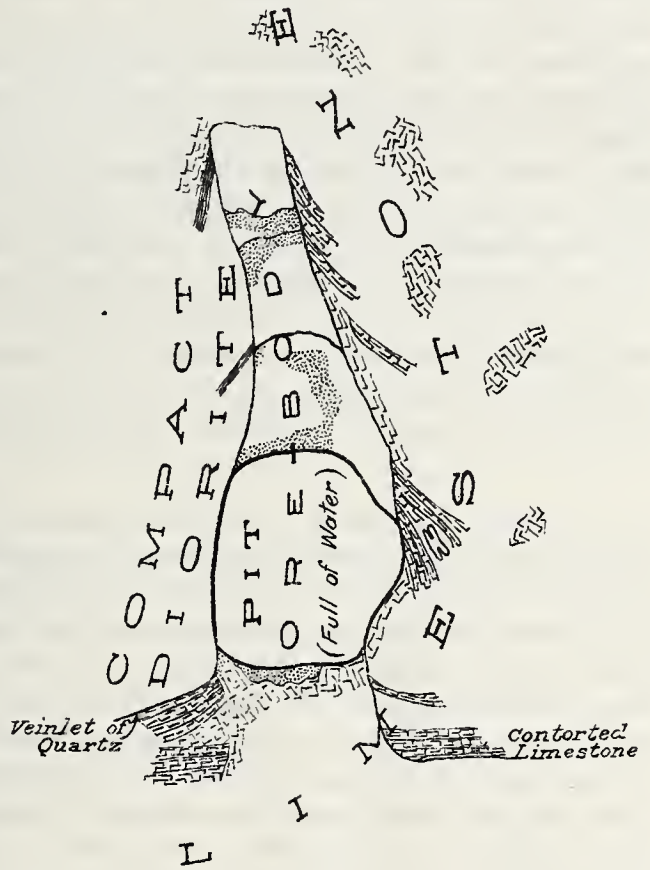
The ore body seems to have ended up against a rather smooth and definite face or wall of the basic rock, whilst where its contact with the limestone is visible, it seems to present more of a mamillated surface, which has a corroded or crystallized appearance.

Ore-dumps.—The ore taken out is all piled near the pit, and measures 50 by 74 by 6 feet, or 22,200 cubic feet, or about 2,700 tons. From an eye examination of the pile, it would seem to be fairly free from pyrite and the sulphur contents should be therefore quite low. Little gash seams of chlorite and calcite seem to be fairly plentiful, constituting perhaps 5 per cent of the whole. The ore comes out in solid lumps, and seems to have a very constant platy or parallel structure, the grain where broken across this structure being fine and steely.*

See Appendix A. * Specimens Nos. 20 and 21. † Specimen No. 21

SKETCH PLAN OF THE YUILL MINE DARLING TOWNSHIP LANARK COUNTY ONT.

Surveyed by E.D Ingall, A.R.S.M. 1895.



Limestone Outcropping

Ore Shewing

SCALE OF FEET
0 10 20 30 40 50

Autographed by Paul Prévenault

BLUFF POINT MINE.

Bluff Point mine.

Bagot Township, Con. X., Lot 16 and Con. XI., Lot 16.

The workings going by this name are situated on the south side of the Madawaska river, just where it issues from Calabogie lake, quite close to the village and post office of Calabogie, which is on the other bank of the river. Near by, runs the main line of the Kingston and Pembroke railway, with which the mine is connected by a spur line about a mile in length. The ore-bodies worked at this place occur in a narrow band of gneissic rock, included in a belt of limestone which latter has a width on the ground of about 2,000 feet. Taking the average dip of the formation here as 30°, this would give thicknesses of about 1,000 feet for the limestone, and about 150 feet for the included gneissic belt. The limestone is bounded on either side by dark coloured rocks of the gneissic series, that to the south, a dark heavy basic rock having been determined, at a point near the Campbell mine, about two miles east of this, to be a plagioclase-scapolite amphibolite *; that on the north having more of a schistose character with cleavage surfaces shining brightly with micaceous scales. The microscopic examination of a specimen from the gneissic hanging-wall rock at shaft No. 1 proved it to be an amphibolite.† The strike of the ore-bearing belt, and of the formation in general, is about N.E. and S.W.

Shaft 1.—The workings here consist of an irregular open-cut in the outcrop of the ore-body at the west end of which a skip road is seen to descend what is evidently an inclined shaft which is now, however, full of water. The skip road at its mouth has an inclination southerly of about 30°. This shaft is said to be about 300 feet deep with no drifting done from it. The eastern part of this working, consists as stated, of an irregular open cut, the face of which, is at present about 10 to 15 feet high. The width to which this has been opened across the outcrop could not however be ascertained as the bottom of the excavation is now occupied by a waste dump. The face as at present visible, however, shows about 10 feet of orey ground made up about as follows in descending order at right angles to the dip of the ore-body. First the gneissic hanging wall rock, then a foot or so of a green chloritic 'selvege,' then two feet of solid ore followed by a small 'horse' about one foot thick of dark compact rock the surface of which is curiously coated with green foliated crystals of a micaceous mineral, probably

* See Appendix A, No. 4. † Idem No. 2.

Bluff Point mine.

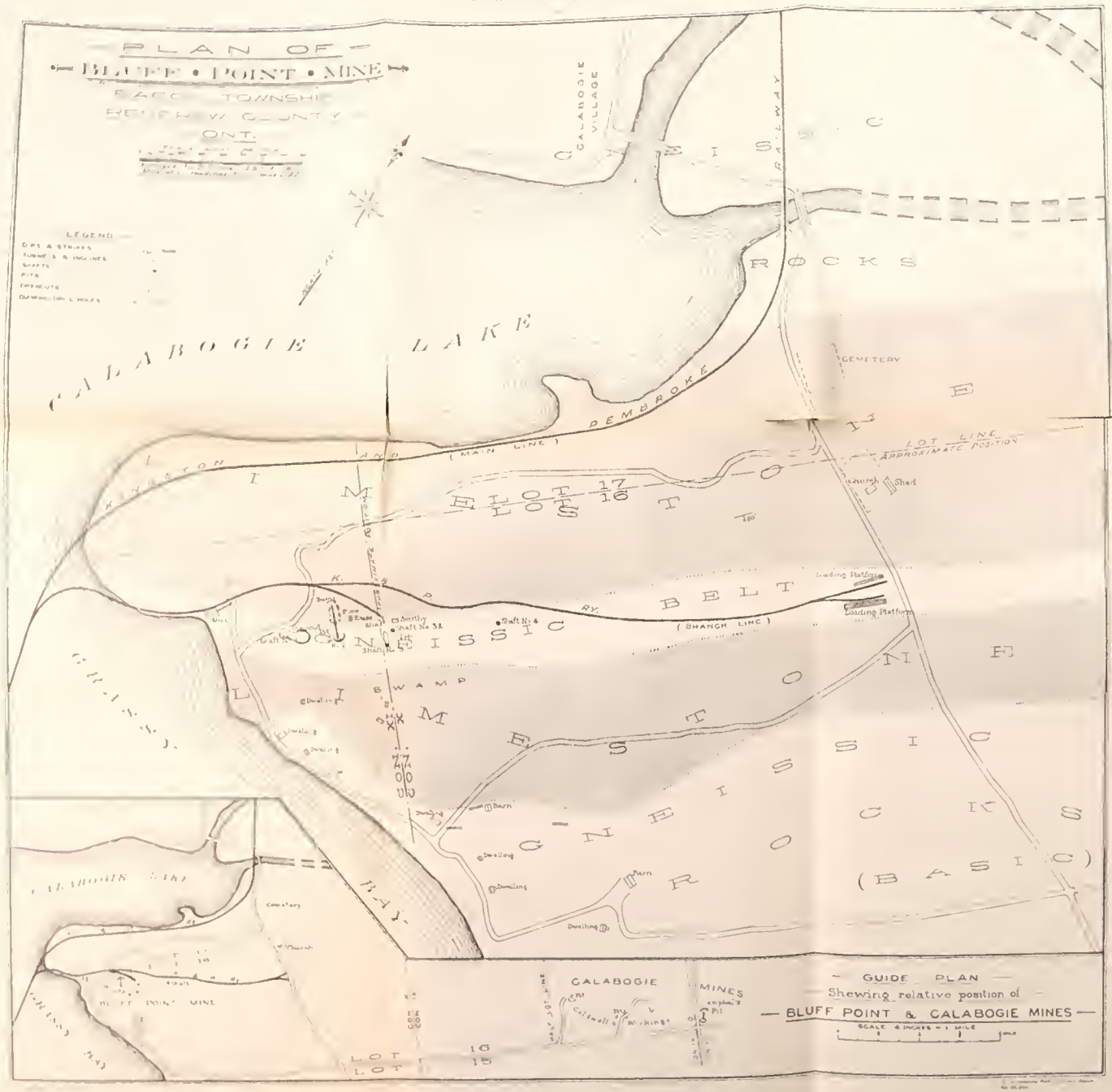
chlorite. Below this about four feet of solid ore and thence down to where the rock face is hidden by the waste material, about five feet of chloritic material with ribs and nodules of ore throughout it. This section is given only as illustrative of the detail of the ore-body at one spot, for here, as elsewhere in the district, it is evident that no such features persist for any distance, and in following the deposit either in length or depth one might run out of poor ground where much rock matter was intermixed with the pure ore, into parts where the mineral was in large bodies, free from such admixture.

Shaft 2.—At this point is a small open cut with an inclined shaft at the bottom. The latter is full of water, so that all that can be seen of the ore-body is its outcropping in the open cut. The cover all round hides most of the features of interest. However, the outcropping shows a rib six feet thick of pretty solid ore besides orey ground above and below the same. Neither wall is exposed, so that it is impossible to state just how much thicker the ore body may be at this place.

Judging from the waste dump the ore here seems to have been intermixed with chlorite, and chloritic and talcose schist. The dip of the excavation as evidenced by the inclination of the skip road above mentioned, is about 40° to the southward and it is said to have attained a depth of about 95 feet. From the bottom of the shaft it is stated that a drift was driven north-east about 70 feet and a large chamber or stope opened out which was said when abandoned to show ore all around with an ascertained thickness of from 8 to 10 feet, without having reached either wall of the deposit. The waste dump at this point consists mostly of chloritic material, and chloritic and talcose schist, in which magnetite often appears in little interfoliated seams, and from this up to more solid seams, the mineral however in the latter case often preserving a foliated structure. Streaks and veinlets of calcite are also frequent and some pyrite shows.

Shafts 3 and 3a.—These are on the next lot to the one last described. The work done consists of a couple of inclined shafts close together. The ore seems to have occurred in the same rusty rotten gneissic rock as at the previously mentioned points. Some specimens of the ore, exhibit similar characteristics to that obtained in the Culhane mines, described later, viz., rusty rotten rock with magnetite in small grains plentifully distributed throughout it.

Shaft 4.—Here a vertical test shaft has been sunk to a depth of 22 feet, in the bottom of which it is said about 5 feet of ore was obtained. The rock showing beneath the thin covering of soil and down to the


PLAN OF
BLUFF • POINT • MINE
CALABOGIE VILLAGE
RAILWAY
GNEISSIC
ROCKS
LEGEND
CALABOGIE LAKE
CEMETERY
PEMBROKE
(MAIN LINE)
LOT LINE
APPROXIMATE POSITION
LOT 17
LOT 16
Church
Shed
Loading Platform
BELT
(BRANCH LINE)
Shaft No 4
Shaft No 3A
SWAMP
Dwelling
Barn
(BASIC)
CALABOGIE
MINES
GUIDE PLAN
Shewing relative position of
BLUFF POINT & CALABOGIE MINES
SCALE 4 INCHES = 1 MILE
LOT 16
LOT 15

water at about 12 feet in depth seems to be a schist with occasionally more compact bands. It dips about 30° to the southward curving over flatter to the northward. Bluff Point mine.

Ore Pile.—A large quantity of ore was, at the time of our first visit, piled up ready for shipment. It was not measured, but from recollection there would be about 1,000 tons. It consisted of magnetite, sometimes of rather granular texture, with chlorite jointed through it and a fair amount of disseminated pyrite. By an eye estimate, the rocky admixture in the ore was put at from 5 to 10 per cent. No signs of pyrites were to be seen in the outcrop at Shaft 1, so that unless it has been all weathered away, it is probably absent at that point, which would thus illustrate the features so common in the ore-bodies of this district, sulphur being absent in some parts and not in others.

History.—Work was started on this deposit some ten years ago, and for one whole summer it is said they shipped 4 car loads per diem. In 1894 it was opened again and some 700 to 800 tons of ore were shipped to the Radnor furnace in Quebec, and operations have been carried on from time to time since. In 1886 it is said that a vessel load of this ore was shipped to Cleveland and gave such satisfaction, that it resulted in the purchasers of the consignment leasing the mine from the owners. For information on those points not personally obtainable by study on the ground, we are indebted to Mr. J. G. Campbell, of Perth, one of the owners.

Magnetic Readings.—On examination of the curves given on the plan it will be seen that a zone of magnetic disturbance can be traced all along the course of the gneissic belt which carries the ore-bodies. These lines, owing to the limited time at disposal, are too far apart to admit of any more detailed results being arrived at, but they certainly give a very good idea of the possibility of finding other ore-bodies worked in the direction of the road easterly from those.

Bagot Township, Con. IX., West, half of Lot 16.

A shallow pit has been made here through the soil at the edge of a beaver meadow on the back of a rib of good solid looking ore which dips at a very low angle southerly. This exposure is said to be about in the middle of the lot. Bagot, IX., 16.

A line of magnetic observations was run about 200 yards westward from this point so as to cross the strike of the formation to see if any trace could be had of the eastward extension of the magnetic zone

noted in connection with the Bluff Point property. The line extended about 1,000 feet either side of the line joining these with the Caldwell and Campbell pits, but no magnetic disturbance was noted.

COE MINE.

Coe mine.

Bagot Township, Con. IX., East half of Lot 16.

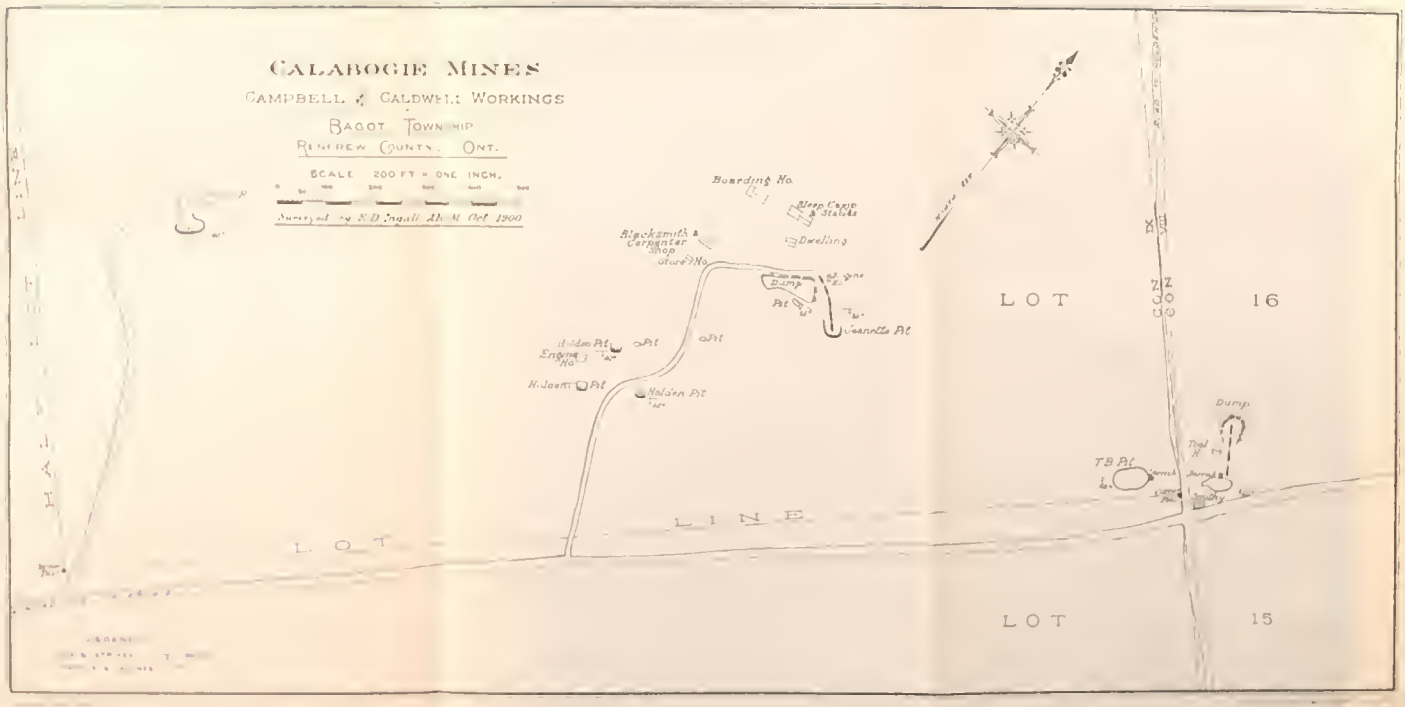
On this lot, which is owned by Mr. Caldwell, of Lanark, a number of ore-bodies have been opened up. Work was begun a number of years ago, and the opening now known as the Jeanette pit was commenced by Mr. Coe, who operated the property under lease. Subsequently the owner had a dip needle survey of the property made, which resulted in the locating of other bodies, development work on which has been done by the Hamilton Steel and Iron Company who acquired a lease of the property. At the time of the examination, made recently, the work was in the hands of individual miners who were taking out and shipping ore to the company on contract. This had to be hauled about a mile and a half by road to the end of the spur line at the Bluff Point mine.

The ore-bodies occur in the dark basic rock already described as bounding the limestone belt of the Calabogie mine on the south and which can be traced along the road located on the lot line as shown in the plan. This has been determined by microscopic examination as amphibolite.*

No limestone could be seen or heard of as occurring in this vicinity in conjunction with the occurrence of the ore-bodies as it does two miles further west. A traverse was made right through to the river along the concession road between VIII. and IX. and across the cleared land of the Holden farm to the north. Along this distance of about 3,000 feet, however, no trace could be found of the limestone belt which, with a width of about 2,000 feet has a strike at the Bluff Point mine which should cause its appearance here. At 500 feet south of the T. B. pit a small belt of limestone is encountered showing a thickness of about 75 feet which would be on the strike of the similar belt which crosses the Darling road a mile further west.

The Tommy R. Pit.—This working was full of water when examined. It consists of an irregular open cut extending about thirty feet along the outcropping of the ore-body and it is said carried to a depth of

* See Appendix A : No. 6.


CALABOGIE MINES
CAMPBELL & CALDWELL WORKINGS
BAGOT TOWNSHIP
RENFREW COUNTY, ONT.
SCALE 200 FT = ONE INCH.
Surveyed by E.D. Ingall A.M.M. Oct 1900
Boarding Ho.
Sleep Camp & Stables
Blacksmith & Carpenter Shop
Store Ho.
Dwelling
Dump
Pit
Jeanette Pit
Holden Pit
Engine Ho.
Pit
Pit
Holden Pit
Holden Pit
LOT 16
LOT 15
LOT LINE
Dump
Tool H.
T.B. Pit
Smithy

about thirty feet. The formation has a dip of about 40 degrees and exhibits an occurrence of ore in amphibolite. At about 130 yards northwards, in a little bluff about twenty-five feet in height, the same basic rock is encountered, showing occasional lighter coloured ribs due to the greater preponderance of felspar, there being more mica and less hornblende in these portions. It is stated that a diamond drill hole was put down near this pit on the hanging wall side to a depth of eighty-four feet, the lower sixty-four feet being reported as through orey ground. Coe mine.

Holden Pits.—About 900 feet westerly from the Tommy R. pit there are three inclines. Two of these are sunk on the same run of ore and the third one on a parallel body about 80 feet north from these. The most westerly had, when visited, a length of about 20 feet on the strike of the body, a height of about eight feet and a depth of about thirty feet. The most easterly of these was slightly smaller. The northern one was very similar but the depth was not ascertainable however on account of water. Located between these and the Jeanette pit are several shallow workings on other ore outcroppings as shown on the plan.

The Jeanette Pit.—At this point an open cut sinking had been made on the dip of a magnetite body at an angle of about 35° which at the time the examination was made had attained a depth of about forty feet, the working so far having opened up a thickness of about eight feet of magnetite.

The T. B. Pit.—This is a large irregular open working about 70 feet by 40 feet and said to be sixty feet in depth though nearly full of water when visited. The upper portion showing above the water is very irregular, pockets of ore having been taken out all round wherever easily accessible. The inclosing rock is much more micaceous and more rotten than at the pits further west. Black mica probably biotite, in crystals about the size of the finger nail occurs associated with the ore-ribs which run through the rock. The work is not in such shape as to define the thickness of the ore-body at this point, but taking the width of the pit in conjunction with the dip of the formation, viz., S. 65° E.$<$ 65°, a proved thickness at the surface of about 35 feet would be shown.

Ore Characteristics.—At the Tommy R. pit, a considerable amount of ore was piled up, probably from 800 to 900 tons. On examination it showed a fine parallel structure with interspersed particles of greenish rock matter and frequent interfoliated seams of the same which at

Coe mine.

places thicken out into small nodules. At the Jeanette pit a pile of over 800 tons of ore was examined when the first visit was made to the mine. It contained ore of good quality in large solid lumps, with a tendency to a platy structure and a slightly granular fracture across the grain. The intermixed material, estimated by eye at about five per cent, seemed to consist mostly of chlorite and calcite disseminated and in veinlets. Little or no pyrite was visible. At the T. B. pit the ore seemed to carry mica, chlorite and calcite as accessory minerals.

CAMPBELL MINE.

Bagot Township, Con. VIII., South half of Lot 16.

Campbell mine.

The workings known locally by this name are situated as shown on the plan immediately across the line from the T. B. pit of the last described property. The excavation made on the ore-body, was at the time of examination about 60 feet in length, and 30 feet in width with a depth of 55 feet. The bottom was not visible, however, as the pit was being cleaned up at the time. It is claimed that a thickness of 17 to 18 feet of ore was obtained in places. The formation dips here E.S.E. $< 60°$. The inclosing rocks are dark, and somewhat schistose, carrying considerable mica and chlorite with harder tough hornblendic ribs. According to the microscopic determination made, it can be classed as a plagioclase-scapolite-amphibolite. It was noticed here, as so often elsewhere, that the ore ribs frequently had chloritic selvages. Considerable ore has been shipped from this point.

Regarding this property, together with the other as one ore-bearing area, it is evident on an examination of the plan, that the bodies of magnetite occur along several parallel ranges and the dip of the rocks gets steeper in going east. The features of the formation in which the ore-bodies occur have already been noted as far as the absence of limestone is concerned, although calcite, probably derived from the decomposition of some of the bi-silicate minerals of the rocks, is found in the ores. Judging from appearances on the ground, and from the microscopic examination made* it would seem as if the rocks inclosing the eastern bodies of ore on these properties show greater evidences of alteration than at points further west.

Magnetic Observations.—The cover of thick bush and the time at disposal for this point, allowed of only one long magnetic cross-section

* See Appendix A, Nos. 4 and 6.

and one short line being made. The latter shows only the attraction of the already known and worked ore-bodies at the Holden pits, the former, besides showing magnetic derangement for the T. B. and Campbell pits, shows the same for some distance either side of this point. The data are, however, entirely too limited to allow of any definite and final conclusions being drawn. Campbell mine.

WILSON OR MARTEL MINE.

Bagot Township, Con. X., Lot 13.

South of the Bluff Point range of workings about a mile, is that known as the Martel or Wilson. The openings are two in number, in a flat of low ground, and being full of water to the top, and the soil covering extending all round, but little can be ascertained on the ground. One of the two pits is a mere prospect hole, said to be about 15 feet deep. The main pit is about 25 feet in diameter. Wilson or Martel mine.

It is stated that the ore-body was 20 feet thick, and dipped about 60° to the S.E., and that about 2,000 tons of ore were extracted and shipped from this point. A small steam hoist and wire rope were used, so that the excavation must have been fairly deep.

The ore-body must have consisted of compact ore, as the waste dump is very small. The inclosing rock, judging from what little shows above water around the edge of the pit, and from the waste dump, is a compact, very fine-grained, and very black, hornblende rock, (diorite*) exhibiting on fracture, a bright, sparkling surface, and at a little distance off, it would be hard to distinguish it from the associated magnetite, so like are they in colour, texture, and general appearance. Throughout the rock are little, gash like areas, as well as larger ones, where the black hornblende is more largely and distinctly crystallized than in the mass of the rock, and where this process of segregation has resulted in a very coarse crystallization, quartz and cleavage masses of calcite are apt to occur, filling up the spaces between the hornblende crystals. Pyrite occurs not infrequently in the same connection. In many pieces of the rock magnetite was seen in seams and veinlets.

The ore, judging from what little yet remains scattered around, is compact and fine-grained, with a tendency to a platy structure. It is often streaked through with small seams of green chloritic material,

* See Appendix A., Specimen 15.

Wilson or Martel mine.

and one or two pieces showed a little disseminated pyrite. It is said to have been very free from sulphur, which report is probably well founded, judging from the infrequency of its occurrence in what remains behind. It is said that about 1,000 tons of this ore was used at the Radnor furnace in Quebec.

Magnetic Readings.—A single preliminary line of dip-needle readings was taken at this point. These were extended in a northerly direction from the main pit for about 150 feet in which distance nothing very remarkable was noted. Going south from the same point, increases in the local magnetic attraction were observed at from 225 to 235 feet from the main pit and at a point about 550 feet measured from the same.

CULHANE MINE.

Bagot Township, Con. VII., N. 1-2 Lot 21.

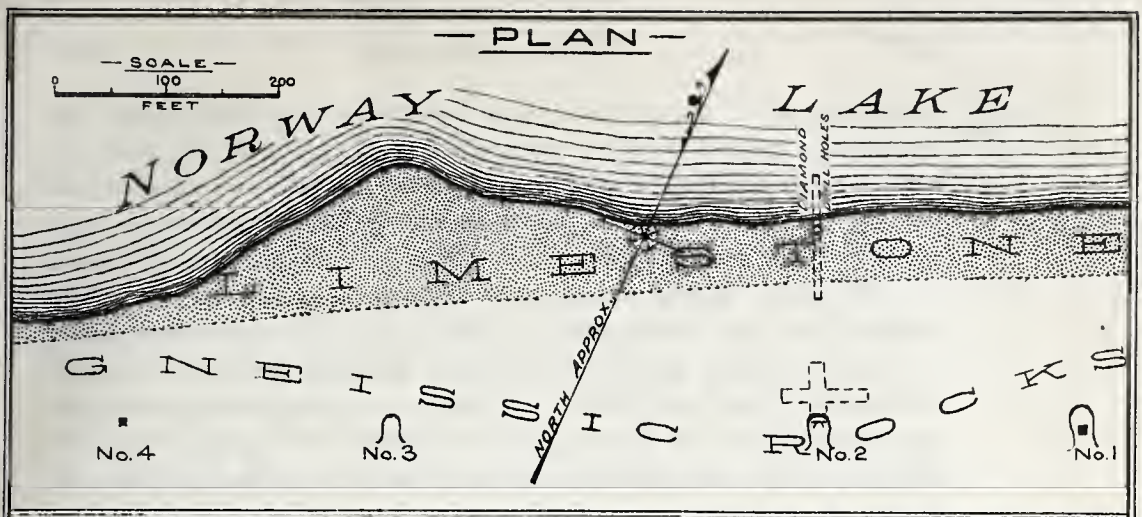
Culhane mine.

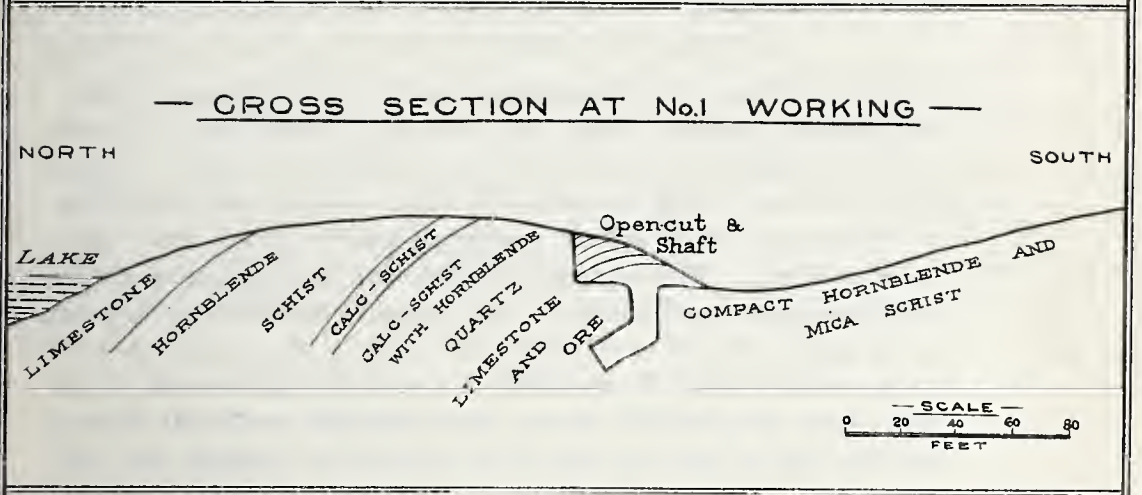
This mine is situated on the south shore of Norway lake. The ore-body runs in a direction a little N. of E. and parallel to the shore, being distant from the same about 200 feet. Four openings have been made upon the ore-body, covering a length of about 900 feet. The mineral belt worked consists of hornblende, calcite and quartz, with plentiful grains of magnetite, etc., lying on compact hornblende and mica-schist rocks which outcrop frequently in a southerly direction. In going north this magnetite bearing calc-schist is seen to be followed by a compact hornblende schist,* and this in turn by a band of crystalline limestone which forms the shore of the lake.

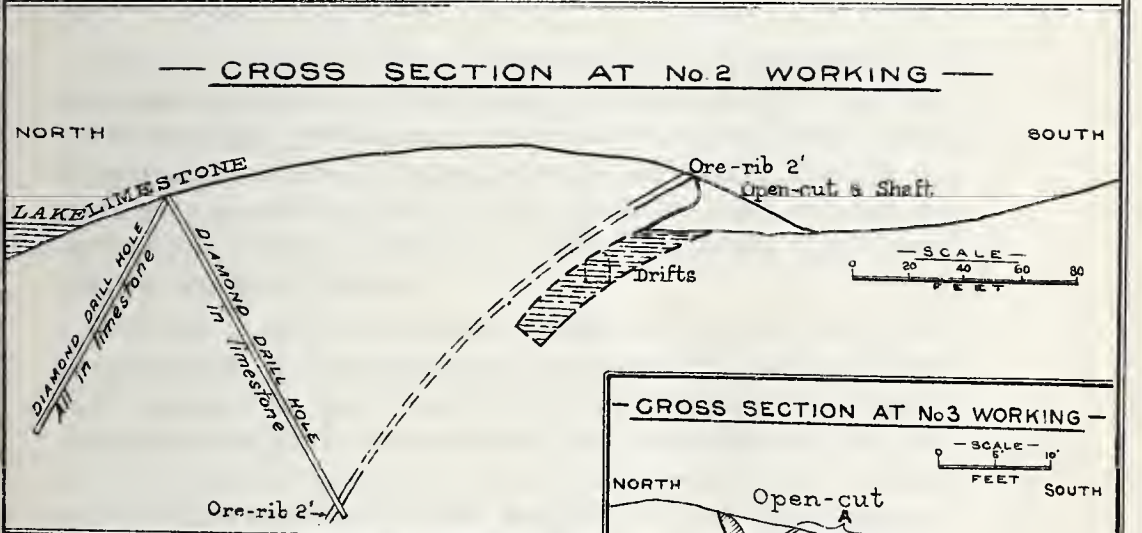
Point No. 1.—At this point is a small open cut about ten feet wide by thirty-five feet long, into the southern face of the little ridge which lies between the mine workings and the lake. From the bottom of this cut a small vertical shaft has been sunk to a depth of about fifteen feet, from the bottom of which the ore has been followed down northward on the slope for about twenty feet. The accompanying rough sketch shows the details of the ore-body and its inclosing rocks at this place. It is stated that no ore of any consequence was taken out here.

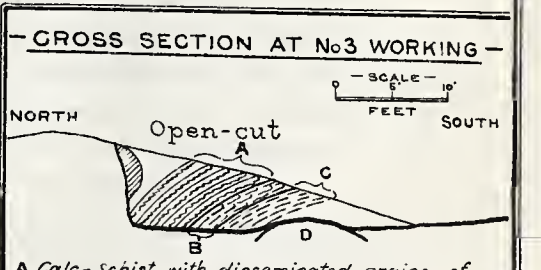
Point No. 2.—About 240 feet west of the last mentioned, lies the main shaft said to be seventy feet deep. It follows the dip of the rocks which on the surface is seen to be about 30° north, but it is said

* See Appendix A, specimen No. 7.









A Calc-Schist with disseminated grains of Magnetite & developments of Actinolite
B Limestone.
C Loose weathering rusty Schist with disseminated ore.
D Compact Hornblende Schist.

— SKETCH PLAN & SECTIONS —
— OF THE —
— CULHANE MINE —
— BAGOT TOWNSHIP. —
— RENFREW COUNTY. —
— ONT. —
Surveyed by E.D. Ingall A.R.S.M. 1895.

Autographed by Paul Frivaudt

that below, the angle of dip was about 10° steeper. The features of the ore-body could only be examined for a short distance down from the surface on account of water. By picking all across the ends of the shaft, however, the ore rib proved to be at least six feet thick, with some little intermixed rock matter, and a little pyrites was also recognized. In the ore are frequent joint planes parallel to the dip and where weathered, it is quite friable. Our guide who was foreman when the mine was working, stated that drifting had been done east and west from the shaft, at a depth of forty feet and that the west drift had a length of twenty-five feet, whilst the length of the east drift was forty feet. In the former the ore-body narrowed somewhat whilst in the latter it kept its size. He further stated that the thickness of the ore in the bottom of the shaft was thirteen feet. Culhane mine.

As far as could be seen above the water-line the hanging wall of the deposit is very distinct, the foot wall being however covered with debris. Above the rib of hard rock forming the hanging wall of the shaft or incline, is a thin ore rib of about two feet in thickness whilst above that again is the calc-schist. To the north, as shown in the sketch, some work was done with the diamond drill. One hole being, for some extraordinary reason, sunk northward and therefore, away from the ore, can be ignored. The other about at right angles to the dip of the ore-body only struck a three foot rib of ore which may represent the above described small ore-rib overlying the main body. The hole stopped in limestone but it does not seem to have been carried far enough to prove much.

Point No. 3.—About 400 feet west of No. 2, a small opening has been made, consisting of a little open cut about twenty-five feet long and six feet deep, the features of which are given in the accompanying illustration. As shown there seemed to be some little evidence of the existence of an anticlinal bend in the rocks at this point, although the working was in such a condition as to leave the question of the southerly dip somewhat doubtful.

Point No. 4.—This is the most westerly work done, being about 240 feet west of No. 3. It consists of a small test pit, the sides of which have so fallen in that it is difficult to see anything. It is stated, however, that it was sunk to a depth of about twelve feet, and that the last three feet was in ore, the body seeming to dip south. Having proved the existence of ore they stopped working. Immediately to the north of the pit compact hornblende-schist is seen to outcrop.

Ore Piles.—It is said that no ore was shipped from here, so that the ore piles now on the ground represent all that was extracted and

Culhane mine.

from them a very good idea can be gained of the kind of material obtained. The pile at the main shaft, would contain about 715 tons of what has apparently been a schistose material with high percentage of magnetite grains, but which has now mostly crumbled to pieces from the action of the weather. At this spot pyrite appears to have been plentiful, existing as grains interspersed with those of the magnetite, as well as, occasionally in little veinlets crossing the structure of the ore. Calcite grains are also frequent. From an eye estimate it would seem that the calcite, pyrite, and other impurities, would amount to from twenty to twenty-five per cent of the ore. It was stated that the percentage of sulphur had lessened, as the deposit was followed downward. A few cubic feet of ore near Point No. 4 show much the same characteristics as that at the main shaft, except that it appears to be more compact.

WILLIAMS, OR BLACK BAY MINE.

Bagot Township Con. XI., Lot 22.

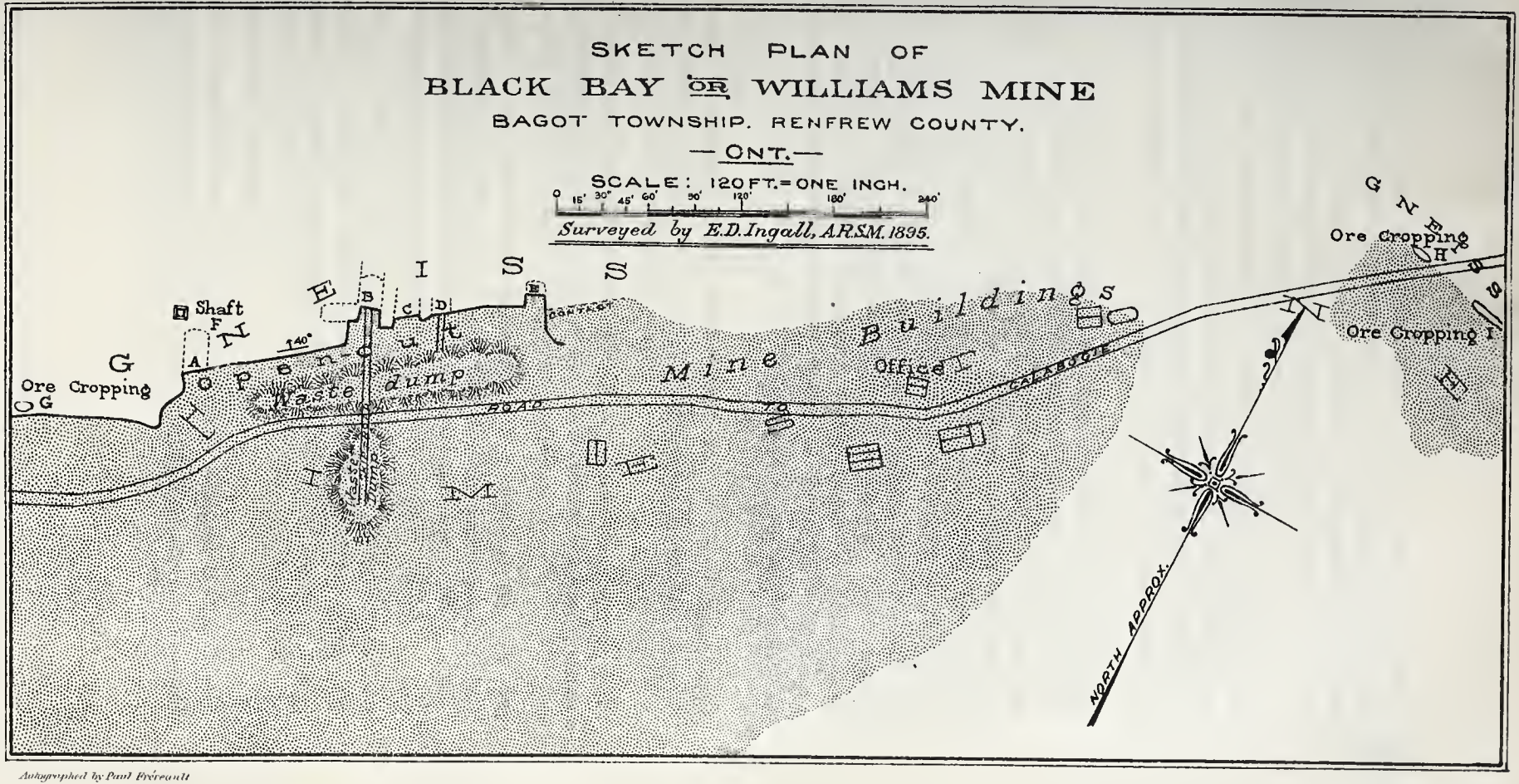
Williams or Black Bay mine.

This mine is situated about two miles north-west of Calabogie station on the Kingston and Pembroke railway.

The rocks in the vicinity of the deposit consist of crystalline limestone, which forms its foot wall, overlain by a heavy basic (hornblendic) member of the series. This latter rock is very compact but on close examination shows a fine parallel or schistose structure.

The strike is about north-east and south-west with a dip judged by the inclination of the workings, of about 40° to the north, the limestone showing all around the south of the workings and forming the sloping floor of the open-cut. The basic overlying rock forms the surface for some distance north. The limestone is of the usual type found in the district, varying from white to grayish and coarsely crystalline in structure.

The proved length of the deposit in the main developments is about 240 feet, although as shown in the accompanying sketch plan, evidences of ore are shown in the small opening G about 100 feet further in a westerly direction and H and I about 600 feet in an easterly direction. The connection of these two latter with the main exposure is however not at all certain, no trace of ore having been found during the examination, in the stretch of rocky ground separating them from the open cut. In fact the ore-body appears to thin out and become indefinite at either end of the cut.



Autographed by Paul Brévoault

Opencut.—The main workings lettered A to E, were full of water, to within a short distance of the top, but they appeared to dip north-northward at an angle of about 40 degrees. The opencut has a face about fifteen feet in height, and beyond that the ore has been followed downward, in several inclines, as shown on the plan. Williams or Black Bay mine.

Point A is an incline sunk in the ore to a depth of about 25 feet. B and D are also inclines which are said to be about 80 feet deep, and to be chambered out below and connected with each other. C and E are only shallow inclines, the former about 25 feet and the latter about 10 feet deep.

An examination of the part of the deposit above the water-level, seems to show that the workable thickness of the ore was variable, and probably interrupted by portions of barren rock or lean ore, the magnetite occurring in basic hornblende gneiss. About the openings of the main workings in the middle of the opencut, the thickness of the ore would appear to have been about 10 feet, but towards the ends it seems to have thinned out and become indefinite, the orey ground being represented by rock containing disseminated magnetite. It is stated that in the underground workings the ore-body measured in places about 20 feet across, but admitted that it varied in thickness. Where ore occurs in the limestone it is mostly in ribs paralleling the structure of that rock.

Point F.—This is a small prospect shaft sunk vertically in the hanging wall rock to a depth of about 22 feet and judging from the material thrown out, did not reach the ore-body.

Point G.—A little ore or magnetite-bearing part of the hanging wall rock, has been exposed by a shot or two. Crystalline limestone, shows in contact with the same, at one corner of the pit.

Point H.—An outcropping of ore about four feet across with the basic gneissic rock above, and the crystalline limestone below. It has a rather scoriaceous appearance, due evidently to the ore being somewhat calcareous and having been weathered to a slight depth.

Point I.—Is a very similar occurrence to the last. An exposure about fifty feet in length and about four feet thick is shown. The ore appears to be rather lean and lies very flat between the gneissic hanging wall and crystalline limestone foot wall rocks as elsewhere. A few shots have been put in.

**Ore Characteristics.*—There is no large pile of ore at this place from which to judge the characteristics of the shipping ore. Some of

* See Appendix A, Specimen No. 1.

Williams or Black Bay mine.

the specimens obtained show considerable intermixture of grains of calcite, some of which weathers brown, and is doubtless a ferruginous dolomite, judging from its slow effervescence with acid. Where the ore occurs in the hornblendic rocks it is much harder and would contain considerable admixed bi-silicates and possibly quartz in places. In the out-crop of the deposit some pyrite was seen but it seemed to be mostly concentrated by itself in seams, etc.

Cost of Mining—It is said that ore mined and shipped from this point to Cleveland, Ohio, cost, laid down there, $4.25 per ton.

Magnetic Readings.—Dip needle readings were taken along four lines at right angles to the strike of the ore-body with only negative results. The particulars were as follow :—Line No. 1—250 feet east of point E. to a point about 300 feet south of the line of strike of the ore-body to an equal distance north of the same. Line No. 2.—From a point 150 feet south of point E to a point about 200 feet north of the same. Line No. 4.—Commencing at opening G and extending northwards for about 350 feet. In the first and last readings were taken every twenty paces and in the second every ten. In none was any particular attraction noticeable in the distance traversed. Line No. 3.—Commenced 200 feet south of point A and was extended northwards past the same a distance of about 350 feet. No attraction was found until A was reached. At that place a fairly heavy downpul was noted which gradually decreased until at about 150 feet past this point the needle had returned to normal.

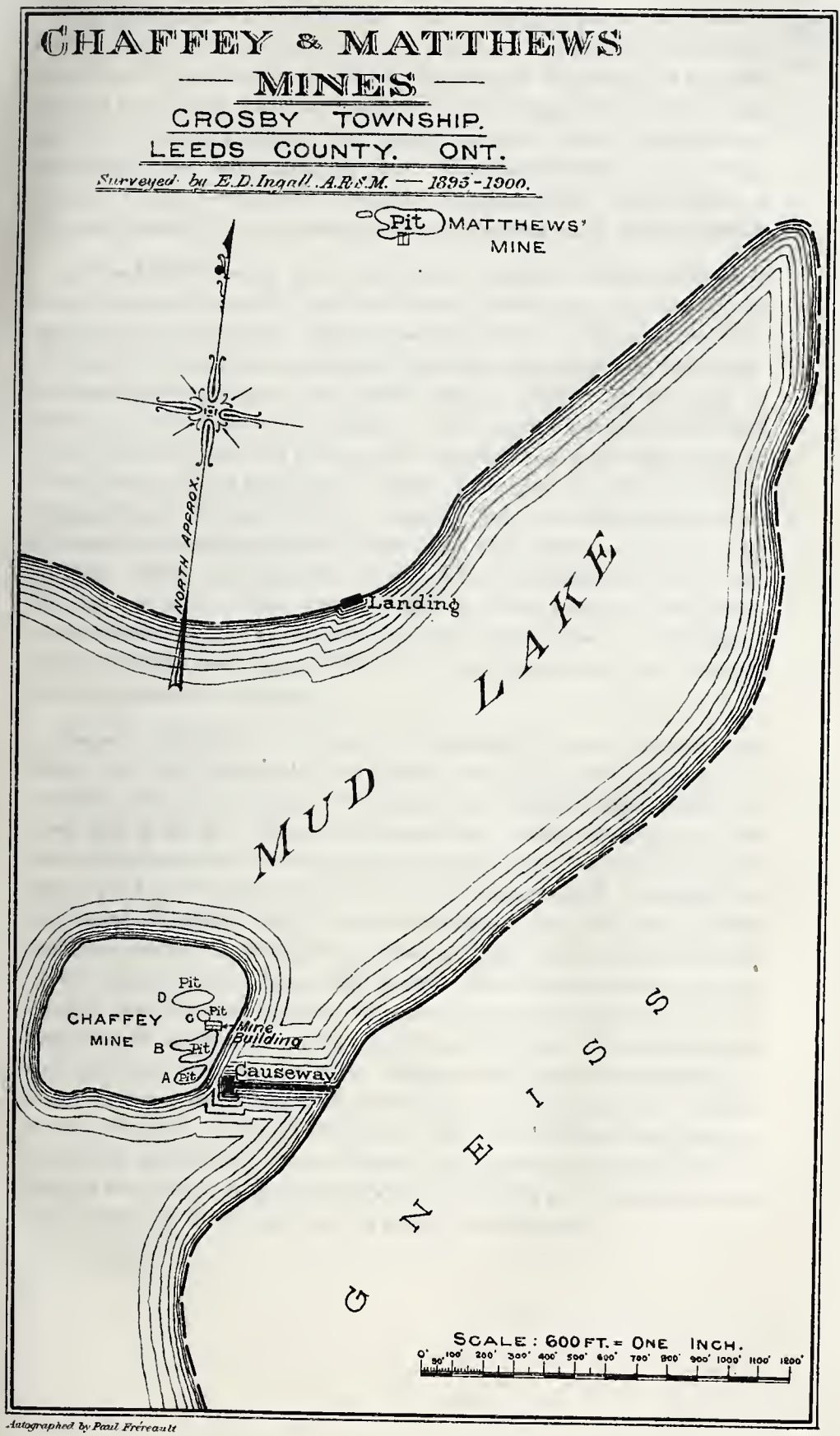
CHAFFEY AND MATTHEWS MINES.

S. Crosby Township, Con. VI., Lot 27 ; N. Crosby, Con. VI., Lot 1.

Chaffey and Matthews mines.

These two mines are situated near each other, and within a mile and a half west of the village of Newboro' on the Rideau canal, between Upper Rideau lake and Mud lake.

The Chaffey mine is situated on a small island but a short distance from the north shore of Mud lake and the Matthews mine about half a mile northward of that point, on the main shore. It will be thus seen that they are exceptionally well situated as regards shipping facilities. Not only does the canal give water communication with the United States and points in Canada, but the Sault Ste. Marie, Westport and Brockville railway passing close by, gives connection with the main trunk lines of the country.



Autographed by Paul Frereault

The geological conditions under which these deposits occur are so similar, that they are best considered together. They seem to represent a number of large but irregular aggregations of magnetite in a coarse grained basic rock probably gabbro. The irregularity of their shape and their relative position with regard to each other, is apparent on examining the accompanying plan. The parallelism of the longer diameters of pits with each other will be noticeable. This direction is also conformable to the general strike of the formation in this district. Chaffey and Matthews mines.

At the Chaffey mine are three large irregular shaped pits, their longer diameters roughly parallel to each other and very close to the east shore of the island. They are separated from each other by walls of barren rock, and have apparently been worked on isolated ore-bodies. In length the three main pits would average about 150 feet and in width about 50 feet at the surface. They were at the time of our visit full of water to the level of the lake, although the walls stand up some 15 to 20 feet above that level. These three pits are said to have an average depth of about 50 feet. Between the two most northerly pits is a small pit said to be but 15 feet deep, and measuring about 40 by 20 feet. These constitute the whole of the workings with the exception of one or two little prospect pits in other parts of the island, which do not seem to have proved any other ore-bodies. As the island itself measures only about 400 by 600 feet, there would not be room for very extensive workings.

Magnetic Readings.—A couple of preliminary lines of readings were taken with the dip-needle, one about north and south, passing the western ends of the pits, and the other in a westerly direction from the west end of pit A. Strong attraction was shown all along the first mentioned, especially between the northern shore of the island and the end of pit D (70 to 85 degrees dip) a slight lessening is recorded from this point to end of pit A (50 to 60 degrees dip) and still greater lessening south from this point, to the southern shore of the island (30 to 53 degrees dip). Along the second line the attraction is much lighter, the reading varying between 20 and 30 degrees, with the exception of one reading of 50 degrees near the pit. The workings at the Matthews mine consist of one large pit with an extreme length of about 300 feet, and width of about 100 feet. According to Mr. Vennor it had attained a depth of 40 feet in 1871. It is full of water almost to the top, and but little can be seen. A gneissic structure is noticeable in the rock at places around the edge of this pit, the strike shown being about E. N. E. and the dip steeply to the north.

Chaffey and Matthews mines.

Magnetic Readings.—Two lines of dip needle readings were taken, one across the longer diameter of the pit, for a distance of about 750 feet northerly, and about 1,200 feet southerly, and one along that direction for a distance of about 350 feet easterly and about 650 feet westerly. Comparatively strong average attraction is shown along all these lines. The readings on the line to the eastward vary between 65 and 75 degrees with a slight lessening at places to from 50 to 65 degrees Passing westward from the end of the pit for about 100 feet, the needle reads from 70 to 80 degrees, then for about 400 feet the variation is between 35 and 45 degrees, lessening to 30 at the extreme western end of the series of observations. The attraction along the line passing south from the pit varies from 30 to 50 degrees, with a few occasional lessenings at places to 30 degrees. Passing northward from the pit for the first 150 feet the readings vary from 50 to 75 degrees, for the next 200 feet they average from 35 to 45 degrees ; for 250 feet more the attraction increases and the readings range between 45 and 55 degrees, lessening again to 30 to 40 degrees at the northern end of the line. To really throw light upon the question of the direction and extent of the extension of the ore-bodies at both of these mines, a much more complete magnetic survey would be required, but as far as they go, the observations would seem to be such as would result from the variation in the quantity of magnetite at different points in a mass of basic rock.

As far as the examination could be carried in the limited time at disposal, there seems to be no reason to conclude that the Chaffey and Matthews pits are on the same bed, which seems to have been the idea entertained by the early operators. On the contrary they seem to represent detached, irregular bodies of magnetite, or local concentrations of that mineral constituent, of a basic igneous rock.

History.—In the Geology of Canada, 1863, the Chaffey mine is mentioned as working in 1858 and 1859, during which period about 6000 tons of ore were mined and shipped to Pittsburg, by way of the Rideau canal and Kingston. Writing later, Mr. Vennor, in the Geological Reports states that in 1871, some twelve men were employed, and 3,500 tons of ore mined and sold. The ore was shipped to Cleveland, Ohio via Kingston. At the mine the ore was said to be worth $2.25 per ton, and delivered at Cleveland it brought $6.00 to $6.50 per ton, and the cost of carriage to Kingston was 75 cents per ton.

In the Report of Progress of the Geological Survey for 1871-2, Mr. Vennor gives the following particulars regarding the Matthews mine.

It had been more or less worked since 1860. During 1871, fifteen men were steadily employed, and upwards of 4,000 tons of ore raised, 3,300 tons of which were sold and shipped to Cleveland, Ohio via Kingston. The same prices were realized as for the Chaffey ore. The total amount of ore sold and shipped to Cleveland from these two mines for the years 1870 and 1871 combined, amounted to 14,520 tons. Chaffey and Matthews mines.

HÆMATITE.

Apart from the study of the above described magnetite deposits, visits were made to a number of points where it was reported that there were occurrences of hæmatite bodies or indications of the same. Hæmatite :— Mode of occurrence.

At one point only had any considerable development been done, viz., at the Playfair or Dalhousie mine, in the township of Dalhousie, Lanark county. At all the other points the reported occurrences were based upon the existence of certain alleged surface indications which had led in some instances to the opening of a few shallow test pits. In some instances the presence of iron ore was suspected on account of the ochreous stained soil and the ploughing up of pieces of iron stained rock. Some of these were found to be merely pieces of sandstone charged with iron oxide to a greater or less extent, the colours varying from yellow ochre to dark red. Along with these, occasional heavier pieces were found containing the iron oxide in larger percentage and more consolidated condition. Some even might be classed as good ore shewing a blue-black compact fracture and all the appearance of hæmatite.

Hæmatitic ore was also seen occurring in the basal beds of the Palæozoic series with outliers of which all these indications seem to be associated. It was seen also at a few places filling "gash" fissures in the underlying crystalline limestone of the Archæan at these points.

From the series of observations made, the impression was left that the ore at these places represented merely casual aggregations of iron peroxide probably resulting from the decomposition of the ferruginous dolomitic portions of the above mentioned sedimentary series They would represent all conditions, from mere ochreous staining of the siliceous parts of the rock through more highly ferriferous sandstones, to masses of loose ochreous material and hæmatite proper according to the extent to which consolidation had proceeded. In places the ochreous decomposition product had leached downward into water-worn cavities and channels in the crystalline limestone wherever this

Hæmatite Mode of occurrence.

happens to be the rock on which the overlying sedimentary beds rest. Wherever these cavities have been large and the overlying rocks highly ferriferous one can understand the possibility of the formation of just such a body of ore as that worked at the Dalhousie mine.

The presence of iron in these basal beds as oxide in various forms both in the arenaceous and dolomitic portions was pointed out in the Geology of Canada (1863) where these rocks were described.

They consist of a series of sandstones, etc., of various colors lying on the denuded surface of the Archæan rocks and forming the lowest beds of the Cambro-Silurian formation. Towards the base they are apt to contain pebbles, sometimes scattered throughout the rock and sometimes in beds. At the very base, is generally a conglomerate made up of similar pebbles. These consist of material, chiefly quartzite, probably derived from the Archæan rocks on which they lie.

The edge of the main area of these rocks lies to the south of the district under description, but numerous outliers are found northward from this. It is possible that some of the more northerly of the ferruginous occurrences noted should be credited to the Calciferous, with its largely developed dolomitic constituents. In this connection it is to be noted that fossils referred by Dr. Ami, of the Survey, to the Calciferous were obtained from near Flower station on the Kingston and Pembroke railway in Lavant township.

The details regarding the various points are given below:

PLAYFAIR OR DALHOUSIE MINE.

Lanark County, Dalhousie Township, Con. 4, Lot 1.

Playfair or Dalhousie mine.

The only developments of any extent on hæmatite ore in this district were those made at the Playfair mine about thirty years ago, several thousand tons of ore were taken from this point and sent to the United States. From the descriptions available the hæmatite shipped seems to have been of good quality.

Here the conditions are apparently somewhat different from those at any of the points subsequently described. A body of hæmatite was found inclosed in the crystalline limestone of the Archæn which is seen to outcrop frequently for some little distance around the workings. There are none of the sedimentary rocks visible in the immediate

PLAYFAIR of DALHOUSIE
— MINE —
— LANARK COUNTY —
ONT.
— From Plan of Gerald C. Brown. —
— Perth, 18th July 1873 —
NOTE The figures in the Longitudinal Section refer to the thickness of the ore-deposit at the various points given
— PLAN —
Road to Perth
Smithy
INDEX
Soil
Soil removed
Ore not removed
Ore removed
Limestone
SOUTH — CROSS SECTIONS — NORTH
Shaft No 1
No 2
No 3
No 4
No 6
No 8
WEST — LONGITUDINAL SECTION — EAST
— SCALE —
GENERAL PLAN
SCALE
Mississippi
River

vicinity of the old workings, although those subsequently described as near Playfairs Mills are only about one mile to the south and there seems to be some evidence of similar occurrences along the north bank of the Mississippi river, to the westward of the mine. Playfair or Dalhousie mine.

The accompanying plan of the workings at this point has been reproduced from the Report of Progress of the Geological Survey of Canada for 1872–3 as it illustrates a number of important features presented by the deposit.* Mr. Vennor in the reports of the survey for 1871–2 and 1872–3 makes mention of the deposit, but beyond speaking of it as a bed of red hæmatite gives no details as to its mode of occurrence.

Dr. Harrington in his notes on the "Iron ores of Canada" published in the Report of Progress of the Geological Survey of Canada 1873–4 gives the following further details. "At one point in the workings, a soft chloritic looking slate with numerous crystals of pyrites, seems to intervene between the ore and the underlying limestone. The limestone is highly crystalline; that underlying the main deposit being white and containing large quantities of tremolite, while that which overlies it is stained red with peroxide of iron. When the mine was opened up there appeared to be two beds cropping out in places at the surface with four or five feet of limestone between them. The uppermost and smaller of these was found to run out at a few feet in depth, and to extend but a short distance in the direction of the strike. The larger deposit was in places as much as nine feet thick at the surface, and at a depth of eighty feet had an average thickness of four or five feet."

In studying the deposit for the purpose of this report the main features illustrated in the plan given herewith were corroborated and some later surface exploratory workings were studied. The old workings were mostly caved in, so that the excavation could only be followed down a few feet, but sufficient could there be seen together with the study of the surface phenomena and the facts revealed by the plans to arrive at a judgment as to the nature of the deposit and its relation to the hæmatitic croppings of other places in the district.

It appears to have been a lense-shape body of hæmatite which showed a tendency to thin out both in length and depth. The whole length of the excavation made was about 500 feet and for about half the distance

* In reproducing this illustration in the report of the Ontario Mineral Commission, p. 139 figures 21 and 22, the scale as here reduced has been erroneously given as 660 feet to the inch instead of 200 feet as it should be which makes the length of the vein developed appear much longer than it really is.

Playfair or Dalhousie mine.

at the eastern end the main body was parallelled by a smaller one, the two being separated by a wall of limestone about 5 to 10 feet in thickness. The greatest thickness of the smaller lense was about seven feet and it seems to have thinned out to nothing both in length and depth. The plans show that in working the main ore-body a similar narrowing was observable in depth and also in passing west, in which direction it would seem to have thinned out to practically nothing. The evidence of the existence of a fault shown between pits Nos. 5 and 6 was not very plain on the ground. Going eastwards a curious feature is noted, viz., that the ore-body did not reach the surface after passing the point "X" on the plan, so that for some fifty feet before arriving at the last shaft (No. 4) the crystalline limestone occupied the surface unbroken by any outcropping of ore. This was corroborated by a careful examination of the ground for several hundred feet to the east of point "X." No signs of ore were found and, the rock exposures being prominent and frequent, the limestone could be traced practically continuously right across the line where the ore outcrop should show and for some distance on either side of it. The operators had evidently also tried to find the outcrop in this direction having driven a long cross trench about 100 feet east of No. 4 shaft in which, however, they had got no trace of ore. Mr. Vennor, in one of his reports, mentions the fact that the ore contains no rock and does not pass into but separates easily from the walls, which are smooth and well defined.

The strike of the ore-body, about E.N.E., and the dip about 60 to 70 degrees southerly conform to the general strike and dip of the rock formation in this vicinity.

In the light of the observations made at this point and of numerous other occurrences of hæmatite in connection with the outliers of the sedimentary series in other parts of the district it would seem that the ore-body at this mine probably owed its existence to similar causes. The peculiar features could be accounted for by regarding it as the result of an infilling of a cavity in the limestone worn out by water along the structural planes of the rock, and filled in from above by such material as is elsewhere found to result from the decomposition of the ferruginous dolomitic portions of the overlying sedimentary beds. That these were once continuous over the whole of this section of the country is apparent, and as before stated, some remains of these beds are yet visible about two miles to the south at Playfairville, where, as already described, they are impregnated with ochreous decomposition products.

It is said that the ore was soft on the top and got harder in depth, shewing a varying degree of consolidation, and a similar infilling of small fissures or cavities in the crystalline limestone was noted at several other places so that taking the smooth walls and all the other features into account, it would seem that this was merely a similar occurrence, only on a much larger scale. Playfair or Dalhousie mine.

Passing westerly along the strike of the ore-body a couple of small test pits were found. The first, about 100 yards from shaft No. 6, on the plan, was full of water to within about 12 feet of the surface, but a few features could be noted in the portion showing. The eastern end showed a few irregular seams of hæmatite a few inches in thickness embedded in a kind of calc-schist, with limestone hanging wall. The foot-wall side of the pit was covered with debris. About twenty-five yards still further west was a small and shallow incline about 15 feet in depth, dipping at an angle of about 25 degrees to the southward. At the eastern end a rusty rib showed, due evidently to the decomposition of pyrite which is here plentiful. Some of the material showed a peculiar fine honeycombed structure, grains of pyrite having been weathered out from a reticulation of quartz. Similar material was found about one quarter of a mile further west in the workings below described.

For a distance of nearly half a mile west of the last mentioned, along the north bank of the Mississippi river, an attempt had evidently been made to trace the ore-body. Several cross trenches and shallow test pits had been made, in which some hæmatitic and ochreous material was obtained, but in most cases it did not seem very certain whether it had been in the solid or was just float ore. At one place a small pile of a few cubic feet of lumps of good ore had resulted, and pieces of float ore, often of good quality, were to be seen on the hill-side and river shore, but the whole probably represents material left as the remnants of previously existent sedimentary rocks.

As all the ore had been removed from around the main workings there was no means of comparing it, in regard to structural details, etc., with other hæmatitic material from this district. Judging from the small amount of waste material the ore must have been very free from admixture. The composition of the ore is illustrated by the analysis given in the table at the end of the report. It will be noticed that there is no determination of the sulphur, although pyrite was noted in places in the deposit. It is reported that the ore was practically free from sulphur. On this point, however, no very authentic data are available.

Mr. Vennor's report gives the ore shipments from 1870 to 1873 as 11,100 tons. According to the same authority, the mine was first opened in 1866.

DALHOUSIE LAKE.

Lanark County.

Dalhousie lake.

Another locality where hæmatite was reported to occur was at the west end of Dalhousie lake in the township of that name. It was found that pieces of hæmatitic and ochreous sandstone had been ploughed up on the farm on the E-$\frac{1}{2}$ of lot 11 in concession XII., and an exposure of the sandstone was seen on the west shore of the lake on the W. $\frac{1}{2}$ of lot 11 in concession XI. At the latter place a little picking had been done and the rock was very loose grained, friable and highly charged with soft red ochreous oxide.

BATHURST TOWNSHIP.

Lanark County.

Bathurst township.

Indications of the occurrences of hæmatite were reported from this place on lots 22 and 23 in concession X. and 21 in concession XI. They were found to consist of a rusty outcropping on the north bank of Bolton brook near where the road crosses it, some lumps of material varying between ochreous sandstone and solid hæmatite ploughed up in a field on Gallagher's farm and similar material obtained in digging a well on Bain's farm near the house. The occurrences present similar features to those in Portland, etc., hereafter described, the sedimentary rocks being in this case represented in a little quarry of white sandstone near Bain's house. A few pieces of rock which had been extracted from a little pit near the same place showed some solid dark hæmatite in crystalline limestone and it was said that a narrow vein of the ore a few inches thick had been exposed in the workings. It probably represented as elsewhere a small "gash" vein in the Archæan rocks filled in with hæmatitic material from the palæozoic rocks formerly overlying the spot.

About two miles north of Fallbrook, at Playfairs Mills similar conditions are found. A short distance to the south of the saw-mill are several shallow test pits in which is to be seen much ochery matter varying from a hæmatitic or compact ochreous material through intermediate grades of similar materials with sandstoney grains and others in which glassy quartz grains shew, to grey sandstone with ochreous

stained areas and unaltered cores some of which are dolomitic as shown by their more crystalline fracture and slow effervescence with acid. Bathurst Township.

The rocks of the immediate vicinity consist of the sandstone lying upon Archæan crystalline limestone.

At points visited in the south-west part of this township conditions were observed very similar to those last described. The ferruginous matter seen, however, was more in the ochrey condition impregnating the rocks, but little of it having been consolidated into the form of hæmatite.

On lot 2, concession IV., were two small and shallow pits which had evidently been sunk on ochreous matter which had collected and become partly consolidated in joints, etc., in the rocks. In one case the appearance presented was that of a vugg in the crystalline limestone filled in as above suggested.

On the eastern half of lot 3, concession IV., some shallow workings were seen where ochreous stain in the rocks was visible. One pit about ten feet deep had been sunk in what appeared to be a red, ochreous, sandstone. Several other shallow workings had been made in the same material within a radius of about 150 feet. All around rise bosses of crystalline limestone, while to the south white sandstone is to be seen lying in a hollow of the limestone. The whole is evidently an outlier of the palæozoic formation carrying in places much dolomite as evidenced by the slow effervescence with acid. This being ferruginous seems to be the source from which is derived the pseudo-hæmatite material which is found filling the jointing of the rocks at the points worked and mostly staining the pieces throughout. Specimens were observed apparently consisting almost altogether of ferruginous dolomite, presenting an ochreous envelope, evidently due to decomposition, and enclosing a core of the unaltered grey rock.

An interesting feature observed in the vicinity of these areas of ferruginous sedimentary rocks consisted in a tongue or small vein of somewhat similar material filling a small irregular crack or gash vein in the subjacent crystalline limestone. It varied from a mere iron-stained crack up to a width of a few inches. The filling was at places somewhat friable iron-stained material, at others it resembled white sandstone. It left the impression of having been a previously existing crack which had been filled in with some of the sedimentary material.

BEDFORD TOWNSHIP.

Frontenac County.

Bedford township.

On the north shore of Birch lake, on the property owned by Mr. J. Bawden, of Kingston, is another occurrence on which a little work has been done. The hæmatite and hæmatitic matter seems in a general way to occur similarly to those already described. The local conditions are such, however, that nothing very definite could be made out in the short time at disposal when the place was visited. Some of the lumps of good hæmatite brought away shew a curious admixture of small crystals of pale mica. Besides this more compact ore the oxide of iron occurs, also in the softer ochreous forms.

STORRINGTON TOWNSHIP.

Frontenac County.

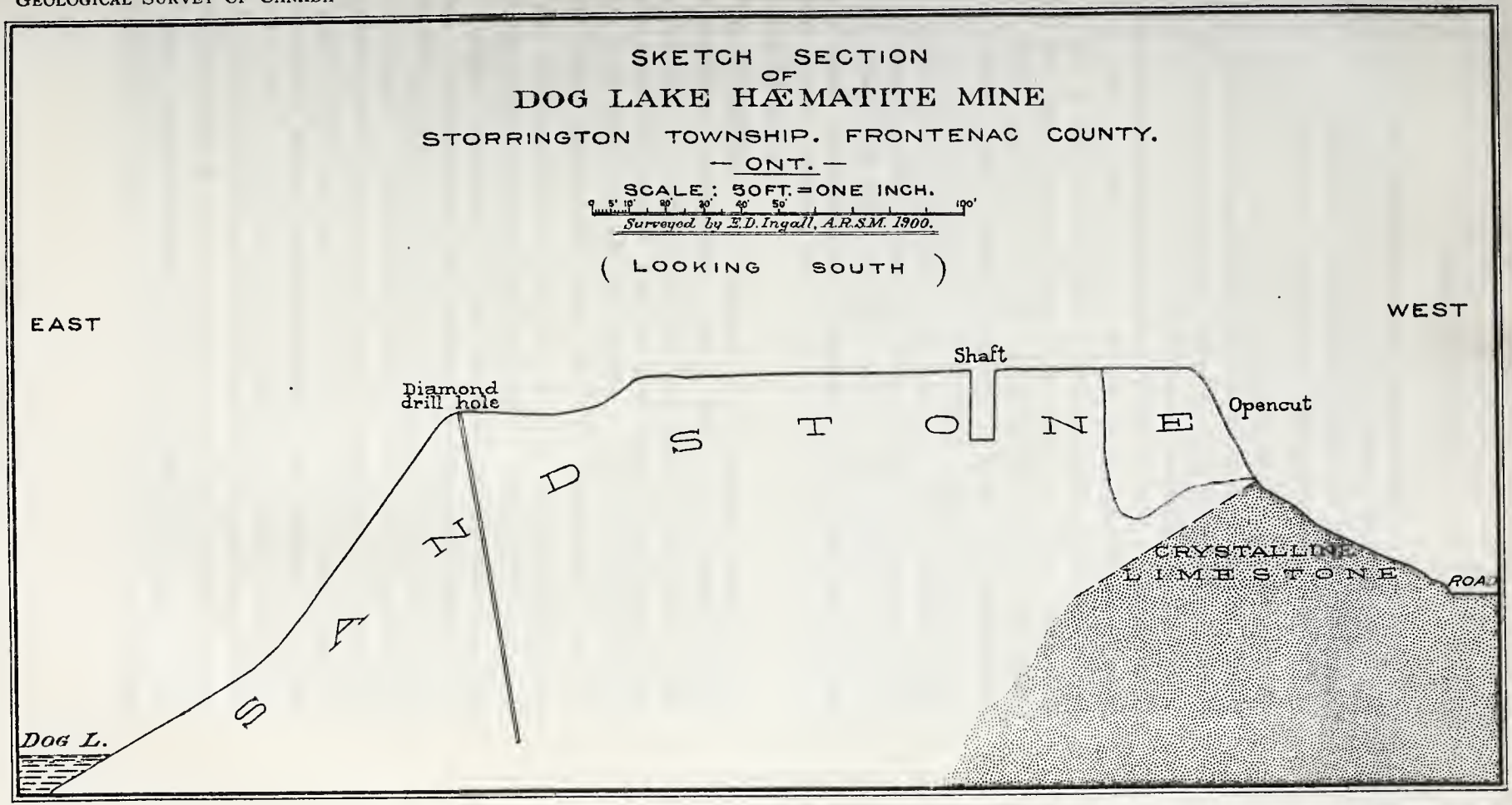
Storrington township.

On lot 20, concession X., a most interesting development is found occupying the neck of land which divides Dog lake from Cranes Nest lake to the north of it.

The ridge of rock occupying this neck is about 100 feet in height above the lake and consists of red sandstone lying on Archæan rocks represented by crystalline limestones which can there be seen close up to and passing under the sandstone. The former as seen in the cliff faces of the ridge shows considerable evidence of false bedding. It carries pebbles of varying size, irregularly distributed, sometimes occurring singly and scattered at others in locally limited layers. A compact weather-resisting glaciated layer forms the top of the ridge, and exhibits some interesting samples of pot holes.

The rock seems to weather very variably, some surfaces being but little affected whilst at other points much corrosion has taken place which has often resulted in the formation of small caverns. These, at places, have for a roof the underside of a layer of pebbles.

It was noted here, as elsewhere that the orey parts seemed to be connected with these easily corroded portions and to be due to the local impregnation of the rock with peroxide of iron in ochreous form as well as occasionally in the more consolidated condition of hæmatite. As in the other cases described, the exposures at this place left the impression that the ferruginous matter had been most likely derived



Autographed by Paul Frérault

from the decomposition of dolomitic portions of the rock carrying iron as carbonate and that this decomposition product had infiltrated into the porous portions of the sandstone filling the insterstitial spaces between the grains and collecting in shattered portions of the same. Storrington township.

The specimens collected show every phase of this process from the mere staining of the sandstone yellow or red to the formation of fairly good ore which on fresh fracture shows the little glassy quartz grains of the sandstone cemented together by compact blue black hæmatitic matter. The final stage of this process is exemplified in some of the specimens collected which consist of really good ore. In these the sandstone grains show only in spots and the mass consists altogether of hæmatite showing a blue black fracture, compact and earthy to partly crystalline, with slight sparkling of minute crystal facets. The characteristic botryoidal structure is developed in places. Where space has permitted, the mineral has crystalized out into the little vuggs in fine platy crystals with bright metallic lustre (specular) and the remaining cavity has been filled in by a white mineral crystallised in platy crystals, with a somewhat radial habit, probably barite. This quality of material would seem to represent the final stage of the consolidation of the ochrey matter collected in the larger insterstitial spaces of shattered portions of the rock.

The soakage effect or infiltration of the ferruginous solution through the sandstone is well shown in many parts, some specimens being mottled the process having stopped short along certain lines, leaving white unaffected portions. This result has been evidently due in many cases to the impervious condition of the rock at these places, the sandstone having become consolidated locally to form patches of quartzite.

The development work done at this place consists of an open-cut into the north-west face of the little bluff, a small shaft on the top of the ridge and a diamond drill hole on the south eastern edge of the same. The open-cut is in the sandstone, extending down about 30 feet from the top of the ridge; about 90 feet along its face, and 25 feet in from the edge. The hæmatitic sandstone shows the features already described and the whole is very much ochre stained. The underlying crystalline limestone, shows at the height of about 30 feet above the road, or half way up from that to the top of the ridge. The little shaft is about 30 feet back from the edge of the open-cut and is about 20 feet deep. At its mouth is a little pile of orey sandstone, showing that rock similar to that in the open cut was encountered in sinking.

The diamond drill hole is said to be about 90 feet deep and to have encountered orey ground at the bottom. In this case the contact plane

of the sandstone and crystalline limestone would be at least 40 feet deeper than on the north-west side of the ridge showing it to dip steeply towards the Dog lake side.

PORTLAND TOWNSHIP.

Frontenac County.

Portland township.

Visits were made to a number of places in the vicinity of Fourteen Island lake, Silver and Long lakes, north of Hartington. In the vicinity were found outlying patches of the basal Palæozoic formation showing the usual features, viz., sandstone of red, and mottled red and white, and white colours with dolomitic portions, the latter often weathering red thus evidencing their ferruginous nature. At some of the points visited the subjacent crystalline limestone was exposed with patches of the basal conglomerate lying on it, often a thin shell only of the same having been left by denudation.

At places there was found the usual association of ochreous and hæmatitic matter in all stages from the loose ochreous to the solid hæmatitic form. On the northern end of lot 5, con. X., some small gash veins of hæmatitic matter were seen in the crystalline limestone, limited in one case by a botryoidal surface. On lot 7, con. X., a pit had been sunk to a depth of about fifteen feet at the contact of the Potsdam and crystalline limestone. The excavation is in a mass of shattered sandstone and conglomerate highly impregnated with ochreous oxide of iron, with occasional pieces of more solid hæmatite. The face of the limestone is covered with crystals of nailhead spar and appears to go down vertically. It may possibly represent a fault plane which would account for the sudden ending of the sandstone up against the almost vertical face of the limestone. The opening is at the base of a little ridge of red sandstone, which shows included quartz pebbles and false bedding. Apart from this small pit no other work had been done in this vicinity which would enable these relationships to be worked out.

A curious association of compact hæmatite with brown jaspery matter and large crystals of schorl was seen on lot 4, con. IX., cropping out through the soil. The exposure was not extensive and the cover prevented its relationship to the rocks of the vicinity from being seen. There seems to be some evidence, however, that it was an aggregation of crystals in the crystalline limestone, the hæmatite portions having probably been derived from the sedimentary rocks previously overlying it.

SOUTH CROSBY TOWNSHIP.

Leeds County.

S. Crosby township.

While passing through the canal locks at Jone's Falls some hæmatitic specimens were collected from a point a short distance along the road passing eastwards from the hotel. As far as could be judged from the short time available there this appeared to be another occurrence similar to those already described.

BASTARD TOWNSHIP.

Leeds County.

Bastard township.

On lot 23, concession X., a small amount of development work has been done on occurrences of hæmatitic material. These show at a number of points. The features exhibited are similar to those of already described deposits, the material being at places, of good quality, at others, consisting of sandstone impregnated with ochreous and hæmatitic matter.

A little work has been done at several points, but only on the surface.

Other Localities.

Other localities.

Besides the previously described occurrences, references are to be found in the report of the evidence taken by the Ontario Mineral Commission in 1888–89 to several other places in the district, where in the opinion of the witnesses there occur indications of hæmatite deposits. Much of this evidence is vague and sometimes contradictory, but on the whole it may be taken as showing the existence at other points of occurrences similar to those personally visited. The localities mentioned are as follows :

Darling Township.—Mention is made by several of the witnesses examined by the Ontario Mineral Commission of indications of the existence of hæmatitic matter in the vicinity of White lake. On page 29 we find these occurrences described as follows : " Where exposed the ore appears as gash veins or irregular masses of hæmatite varying from 6 inches to 12 feet wide, and occurring in a breccia of calc-spar with the same as a lime matrix and the general run of the ore is with

Other localities.

the formation. In places the hæmatite is the matrix of the calc-spar masses. Openings have been made in several places but very little work has been done on the property."

Dr. Ells visited this point in 1896 and says that the ore occurrs "in the crystalline limestone formation in connection with which no eruptive rocks were visible."

Bathurst Township.—W. J. Morris' evidence. Indications of hæmatite on both sides of Bennett lake at low water.

North Elmsley and North Burgess Townships.—It is reported that indications of hæmatite are found at a number of points in this area. As the edge of the main area of Palæozoic rocks is near by, these are probably also connected with outliers of these rocks on the Archæan.

Some little work said to have been done at Adams lake on hæmatite indications.

Leeds County.—R. C. Sherret, in his evidence makes mention of an occurrence at Charleston lake, a specimen from which is said to have yielded on analysis 70 per cent of iron.

Addington County.—In the before mentioned report of the Ontario Mineral Commission an occurrence is described as follows: "Hæmatite mixed with a dark coloured shale occurs near the village of Tamworth, at the terminus of the Napanee and Tamworth railway, in the township of Sheffield, county of Addington. Several pits have been sunk at points from 20 to 100 feet apart, from some of which red ore has been taken out; but in every case the pits ran into crystalline limestone which underlies the occurrences of ore, and crops out about 200 feet off. The quality of the ore varies from very lean to rich hæmatite, but there are no signs of the existence of it in large quantities."

According to the evidence of Mr. Leonard Wager (*vide* same report) the above mentioned pits were about ten feet deep when they encountered the crystalline limestone. The ore passed through showed a thickness of about three feet and rested on the limestone. About twenty-five tons of ore were extracted.

APPENDIX A.

MICROSCOPIC EXAMINATION OF SECTIONS OF ROCKS ASSOCIATED WITH THE IRON ORE DEPOSITS OF THE KINGSTON AND PEMBROKE RAILWAY DISTRICT BY A. E. BARLOW, M.A., D. SC., PETROGRAPHER TO THE GEOLOGICAL SURVEY OF CANADA.

Microscopic Examinations of rocks.

No. 1.—Williams or Black Bay Mine.—Lot 22, Concession XI., Township of Bagot, Renfrew County.

The hand specimen shows a heavy black, evidently highly ferriferous rock, traversed by bands of much lighter-coloured material, most of which is calcite.

The magnetite which is by far the most abundant mineral represented in the slide, occurs in irregular individuals and areas, including, as well as separated by, smaller individuals and areas of felspar and calcite together with a much smaller proportion of hornblende and chlorite. Pyrite, in considerable amount is very intimately associated with the magnetite. The larger and more continuous areas are composed almost entirely of calcite. It is impossible from the slide to state what the rock has been originally. It may be a highly ferriferous gabbro which has undergone pronounced alteration, or an impure crystalline limestone.

No. 2.—Bluff Point Mine, Calabogie.—Lot 16, Concession XI., Township of Bagot, Renfrew County.

The hand specimen is a medium-textured dark-gray gneissic rock. (Amphibolite.)—Under the microscope it seems to be composed essentially of felspar and hornblende. Felspar is the more abundant and although a considerable portion is striated a large amount is unstriated. Separations of similar rocks from areas in Hastings county have been made by means of Thoulet's solution and show the felspar to be almost altogether labradorite. Good foliation, produced chiefly by the parallel alignment of the hypidiomorphic individuals of hornblende. Sphene is abundant in irregular, usually more or less rounded individuals.

Microscopic Examinations of rocks.

Apatite in stout imperfect and rounded crystals is likewise abundant. Pyrite and magnetite are sparingly represented. Calcite is present apparently as a product of decomposition of the felspar.

No. 3.—Bluff Point Mine, Calabogie.—Lot 16, Concession XI., Township of Bagot, Renfrew County.

The hand specimen shows a black glistening metallic rock which is evidently in great part composed of magnetite. Pyrite is also abundant and on planes of shearing greenish decomposition products have been developed. The thin section as might be expected is composed largely of magnetite, together with a much smaller proportion of pyrite. Cracks and interspaces are frequent, which are filled up with calcite, chlorite, sericite and occasionally a little augite.

No. 4.—Campbell Mine—Lot 16, Concession VIII., Township of Bagot, Renfrew County.

The hand specimen shows a rusty-weathering, dark greenish-grey, almost black, basic schistose rock with occasionally narrow bands of pyrrhotite. Under the microscope it is seen to be composed mainly of felspar and hornblende. One side of the slide shows the felspar wholly replaced by scapolite which seems to be an alteration product of the plagioclase. The cleavage cracks and fissures of the scapolite are filled with yellowish-green serpentine or chloritic products derived, mainly at least, from the decomposition of the hornblende. Most of the scapolite, on account of the abundance of these decomposition products polarizes in dull bluish and pale-yellowish tints, but in places where it is fresher it shows an approach to the usual brilliant chromatic polarization. The foliation is marked chiefly by the parallel alignment of the hypidiomorphic hornblende although the other minerals show a marked tendency towards similar parallelism. Most of the felspar is unstriated but from its association it must belong to the basic end of the plagioclase series. Apatite and sphene are both rather abundant. Magnetite is abundant, and pyrite in much smaller quantity. The rock may be called a plagioclase-scapolite-amphibolite.

No. 5.—Christies Lake Mine.—Lot 18, Concession III., South Sherbrooke Township, Lanark County.

The hand specimen shows an interfoliation of a dark-gray almost black, glistening basic schist with a pale-yellowish gray, massive and

more coarsely crystalline rock. The thin section is of the darker coloured portion and shows this to be a very fresh and typical plagioclase-scapolite-diorite. Most of the felspar shows the polysynthetic twinning lamellæ, although a considerable proportion of the grains are untwinned. It is probably a basic plagioclase. It occurs side by side and embedded in the scapolite both minerals being very fresh, in very irregularly shaped, evidently allotriomorphic grains. The line of contact between the two minerals is very sharp and the only evidence of the derivation of the scapolite from the plagioclase is the fact that what may be still unaltered portions of the latter occur completely surrounded by the former. The hornblende is the compact dark-green variety, and has the usual rather perfect cleavage, in irregular individuals with little or no attempt toward crystalline outline. The pleochroism $\mathfrak{a}$ light-yellowish green, $\mathfrak{b}$ dark green, $\mathfrak{c}$ deep bluish-green is very marked, as is also the absorption $\mathfrak{c} > \mathfrak{b} > \mathfrak{a}$. Deep brown pleochroic biotite occurs for the most part embedded in or intimately associated with the hornblende. Occasionally it occurs as a parallel intergrowth. A deep clove-brown pleochroic sphene, in irregular and large individuals, is also very abundant and frequently occurs completely inclosing an opaque iron ore, probably ilmenite. Apatite is also abundant in irregular or rounded prismatic forms. Pyrite was noticed in occasional individuals completely inclosed in the hornblende. Microscopic Examinations of rocks.

No. 6.—Coe Mine.—East half Lot 16, Concession IX., Township of Bagot, Renfrew County.

Amphibolite.—The hand specimen represents the familiar dark-coloured basic, highly schistose bands familiar to Archæan geologists, which so frequently alternate with the light-gray and reddish bands and taken together are so typical of the gneissic rocks usually classified as Laurentian. All the minerals show a very marked parallel arrangement while the schistosity or cleavage is accentuated by bands prevailingly rich in biotite. Some of the felspar is striated but a large proportion of it is unstriated while many of the individuals show the sharp extinction usually considered as characteristic of quartz. The thin section shows the rock to be composed chiefly of felspar, hornblende and biotite. Separations have been made by means of Thoulet's heavy solution of several specimens of precisely analogous composition from the country to the west of this area which show clearly, that orthoclase and quartz are entirely absent and that the prevailing light-coloured constituent is a normal labradorite. The hornblende

Microscopic Examinations of rocks.

is more abundant than the biotite. Apatite is rather plentiful and a little calcite is noticed which has evidently not been derived from the decomposition of any of the other constituents. Occasional areas of a yellowish green serpentineous product occur evidently derived mainly from the decomposition of the hornblende.

No. 7.—Culhane Mine.—North half Lot. 21, Concession VII., Township of Bagot, Renfrew County.

The hand specimen shows a very dark greenish-gray distinctly foliated though somewhat massive basic rock with occasional small patches of light coloured and decidedly more acidic material.

Under the microscope the rock is seen to be a rather typical diorite. Hornblende, which is the most abundant constituent is the compact variety in irregular individuals the interspaces between which are occupied by the allotriomorphic plagioclase. Some of the felspar is striated but a large proportion at least of the unstriated grains are also probably plagioclase. Apatite is present and a little quartz. Very occasional small scales of biotite also occur. Magnetite in small irregular grains and pyrite sometimes altering to limonite are also present. One side of the thin section evidently represents a portion of a decomposed band and is made up of pale greenish chlorite and calcite.

No. 8.—Fournier Mine.—Lot 14, Concession I., Township of South Sherbrooke, Lanark County.

This mine is represented by three thin sections (8, 9, 10) and all are typical of the rock which the late Prof. G. H. Williams called "cabbro-diorite." They present different phases of the rock and a detailed description of each slide will be given.

The hand specimen from which section No. 8 was taken is a very massive, coarsely crystalline basic igneous rock, the principal constituents being easily capable of determination with the naked eye. Under the microscope the rock is seen to be composed of comparatively large individuals or areas of a basic plagioclase, and a pale-green pyroxene. Some of the plagioclase is quite fresh and glossy, but the interior of nearly every individual is very turbid and more or less opaque owing to the development of saussurite. The products of decomposition seem mainly to be kaolin or sericite and calcite. The fresh periphery often shows more or less advanced alteration to scapolite, and a few of the smaller individuals are wholly converted

into this material. The derivation of the scapolite from the plagioclase seems undoubted, and if further corroboration is needed an inspection of the other two slides (9 and 10) would convince the most sceptical of this interesting fact. The augite is very largely in process of alteration into a deep green, strongly trichroic hornblende, and no better or more instructive example of uralitization could be desired. A little sphene and calcite are both represented in the thin section. Some of the individuals of pyroxene show what is usually referred to as 'schillerization products' consisting of dots and dashes of a brownish, nearly opaque material, arranged in parallel lines at right angles with the cleavage. These are more perfectly developed in the unaltered pyroxene, but generally fade away, disappearing altogether in the uralite. Microscopic Examinations of rocks.

No. 9.—Fournier Mine.—Lot 14, Concession I., Township of South Sherbrooke, Lanark County.

Is a dark-gray basic rock, much finer-grained than the specimen from which No. 8 was taken, and shows a decided foliation, consisting for the most part in the alternation of lighter and darker bands. It is, however, very similar in composition. The chief constituents are plagioclase, scapolite, pyroxene and hornblende. The derivation of the scapolite from the plagioclase is undoubted. The scapolite constitutes more than half the lighter portion of the slide. Much of the scapolite and plagioclase contain numerous very fine rod-like inclusions which intersect each other at various angles. The uralitization of the pale-green pyroxene is much more complete, and most of the individuals are wholly converted into a dark-green compact, strongly trichroic hornblende; many fragments, however, still show remnants of the unaltered pyroxene, so that the source of the hornblende is undoubted. A little biotite is present, as also apatite, pyrite and sphene. Some of the sphenes contain black opaque cores, probably ilmenite. Calcite is abundant.

No. 10.—Fournier Mine.—Lot 14, Concession I., Township of South Sherbrooke, Lanark County.

No. 10 is taken from the same hand specimen, closer to the ore body. Indeed it forms the rock immediately in contact with the iron ore. The band from which it was cut is of a dark-green colour, brightly glistening on planes of cleavage, and showing, microscopically, only a very small proportion of the felspathic constituents. Under

Microscopic Examinations of rocks.

the microscope by far the most abundant constituent is a deep green, strongly trichroic hornblende. Its derivation from the pyroxene is likewise undoubted, as one side of the thin section shows cores and areas of the unaltered mineral still surviving. Plagioclase is present and much of it is unstriated. Scapolite is only sparingly represented if at all. Biotite is much more abundant, in larger individuals than in No. 9 and so also is sphene. Nearly all of the opaque mineral present is pyrite, but some is ilmenite. Epidote is also present.

Nos. 11, 12, 13 and 14.—Glendower Mine.—Lot 6, Concession III., Township of Bedford, Frontenac County.

The least altered representative hand specimen from the Glendower mine shows a rather coarse-grained, massive, dark coloured basic rock; a pale yellow mineral is very conspicuous, which on examination proves to be scapolite. Under the microscope the rock, (No. 13) is seen to be what may be called a 'plagioclase-scapolite-gabbro;' a few individuals of the original plagioclase, occurring, for the most part in untwinned grains, still remain, but by far the larger proportion has been altered into what, in thin section, is colourless scapolite but which in the hand specimen is the yellowish mineral mentioned above in the macroscopic description. As mentioned by Adams and Lawson*, the polarization colours are usually very brilliant but sometimes pass through orange and yellow to the dull bluish-gray tints usually characteristic of the felspar so that it is impossible in every instance to distinguish between these two minerals. Occasionally, as noticed by Adams and Lawson, in their examination of the scapolite-diorite from near Arnprior, Ont., traces of polysynthetic lamellæ were observed in which the extinction though much less distinct, than in plagioclase resembled it otherwise very closely. The appearance is very suggestive of the derivation of the scapolite from plagioclase, and if this be the case the twinning structure of the latter is retained after the mineral has apparently been entirely changed to scapolite. Probably, however, in these cases the change may not be complete, and although the mineral has the characteristics of scapolite there may be sufficient plagioclase remaining in twinning position to cause the alternate oblique extinction observed. The index of refraction of the scapolite of the Glendower mine is, however, considerably higher than that of the accompanying plagioclase. The pyroxene has a somewhat faint though decided pleochroism, a yellowish, b greenish, c

*On Some Canadian Rocks Containing Scapolite. Can. Rec. of Science, vol. III, page 19. Oct. 1888.

light-green. It occurs in irregular individuals, penetrated and surrounded by the alltriomorphic scapolite and plagioclase, and shows incipient alteration, chiefly marginal, into a green strongly trichroic hornblende. A deep clove-coloured pleochroic sphene, evidently rich in iron in large irregular fragments, is abundant, as is also apatite in irregular grains and large rounded prismatic forms. A little calcite is also present. Another thin section examined showed the plagioclase entirely converted into scapolite. The hand specimen thus represented might be called a scapolite-gabbro. Microscopic Examinations of rocks.

Another specimen examined (No. 12) showed in the hand specimen a basic gneissic rock. Some of the bands are of light-grayish colour, with patches and streaks of pale reddish (scapolite) and greenish (hornblende) mineral. Angular fragments, as well as bands of dark-green amphibolite and diorite occur, while disseminated throughout the whole in grains and patches, is a comparatively large amount of a very pale yellow pyrite.

Under the microscope the lighter portions of the rock are seen to be composed mainly of a basic plagioclase (anorthite ?) which has apparently been altered in places into scapolite (wilsonite?). Calcite which may have resulted from the further alteration of the plagioclase, and a much smaller proportion of a green hornblende and still smaller quantity of quartz are also present. A few of the unstriated grains may be orthoclase. The darker or green portions and bands are composed mainly of hornblende together with a much smaller proportion of plagioclase and scapolite.

The scapolite-gabbro above described, may, by an increase in the ferro-magnesian constituent, pass over into a pyroxenite but such a type is unrepresented by any of the hand specimens in the collection examined. One thin section examined, however (No. 11) which might be described as such, had evidently been taken as representative of the ore-body, as is seemed to be composed mainly of magnetite with a very subordinate amount of pyrite. This is surrounded and contains embedded in it the same green pyroxene, already mentioned, undergoing alteration to hornblende and serpentine. Both of these alterations may be seen plainly, in the slide. Sometimes the change from pyroxene to serpentine is direct, but at times the hornblende serves as an intermediate stage in the process. Secondary calcite is rather abundant and the belief is entertained that some of it may have been derived from the decomposition of scapolite originally present but the facts presented in this section in support of this view are not incontrovertible. A small amount of dolomite was also noticed.

Microscopic Examinations of rocks.

Another closely related rock and one which may have been derived from the alteration of a pyroxenite, if such be present in any appreciable quantity at this locality, shows in the hand specimen an almost black glistening basic schistose rock which in thin section under the microscope is seen to be composed almost wholly of green trichroic hornblende. There is little or no felspar present. Magnetite is rather abundant in irregular grains together with a small proportion of pyrite.

The most decomposed portion of the whole rock mass is represented by two thin sections (No. 14). It evidently represents the extreme alteration of a rock which was originally a pyroxenite or an extremely basic amphibolite.

The hand specimen is very fine-grained, compact and only very slightly greasy to the touch. Under the microscope it is seen to be mainly composed of a greenish serpentinous product, noticed in the other sections as resulting from the alteration of pyroxene ; small cores of the latter still remain and the mesh-like structure is very similar to the serpentine resulting from the decomposition of olivine. Calcite is abundant, as is also magnetite, the latter mineral filling what appears to be irregular fissures and interspaces in the rock.

No. 15.—Martel Mine.— Lot 13, Concession X., Township of Bagot, Renfrew County.

Macroscopically a dark-green almost black, fine-grained rock with irregular streaks, patches and spots of magnetite and pyrite disseminated throughout.

Examination of the thin section shows the rock to be a typical diorite, composed chiefly of hornblende and plagioclase. Some of the plagioclases exhibit the twinning striae, but the larger proportion of the felspar consists of untwinned grains and most of this, at least from its association is probably plagioclase. As a rule it is quite fresh, but some of it decomposed into a saussurite aggregate of which calcite is the prominent constituent. The hornblende is the compact green pleochroic variety, some of it altered into a green chlorite. Apatite in comparatively large prisms is abundant as is also sphene. Most of the opaque mineral is magnetite although pyrite is also rather plentiful.

No. 16.—Ritchie Mine.—Lot 16. Concession VII., Township of S. Sherbrooke, Lanark County.

Microscopic Examinations of rocks.

Macroscopically a pink-coloured gneissic granitoid rock. The foliation is chiefly marked by narrow bands of dark-greenish material. Under the microscope it is seen to be a scapolite-augite-syenite-gneiss. The minerals present are orthoclase, microperthite, plagioclase, scapolite and pyroxene, with small quantities of sphene, apatite, magnetite and occasional scales of biotite. The pyroxene is in irregular grains, is of a deep green colour, and shows a faint though decided pleochroism. In a few individuals incipient alteration to a deep-green hornblende was noticed. The scapolite may be plainly distinguished from the felspar by its brilliant chromatic polarization, high index of refraction and the presence of the cleavage cracks filled with a yellowish decomposition product. The sphene is in large rounded lumps and together with the rounded prisms of apatite is for the most part intimately associated with the pyroxene. Quartz seems to be entirely absent.

No. 16a.—Ritchie Mine.—Lot 16, Concession VII., Township of Sherbrooke, Lanark County.

The hand specimen shows a dark-green, almost black, somewhat coarse massive crystalline rock. Under the microscope it is seen to be a diorite. The plagioclase, which is in very small amount, is largely altered to calcite, together with a little epidote and chlorite. The very abundant hornblende is of the usual compact dark-green variety. Magnetite is present, mostly associated with the decomposed plagioclase. Apatite is present in occasional large rounded individuals. Calcite may frequently be noticed embedded in the hornblende in sharp individuals.

No. 16b and 16c.—Ritchie Mine.—Lot 16, Concession VII., Township of S. Sherbrooke, Lanark County.

Are taken from the same hand specimen, which shows a pale flesh-red massive granitoid rock in contact with a dark-gray more basic schistose rock. The line of contact is quite sharp, and the acid portion appears to be the newer. Under the microscope the red granitoid rock is seen to be a syenite composed of orthoclase, microperthite, oligoclase, albite, with much smaller quantities of hornblende, biotite, sphene, and magnetite. The coloured constituents are in small irregu ar

Microscopic Examinations of rocks.

more or less separated individuals, and are barely sufficient to characterize the rock. The basic schist is a very typical and fresh scapolite gabbro. The green pyroxene has a faint though quite distinct pleochroism, yellowish and greenish. It shows only incipient alteration to to deep-green hornblende. Sphene is present in irregular individuals. In spite of the evidence of intrusion of the syenite through the scapolite gabbro, and this comparatively sharp line of contact, it is possible that both may represent differentiated portions of the same magma. One strong evidence of this fact is the presence in both of the same green pleochroic pyroxene.

No. 16d.—Ritchie Mine.—Lot 16, Concession VII., Township of Sherbrooke, Lanark County.

The hand specimen shows a flesh-red well foliated, evidently highly felspathic, granitic rock. The foliation is marked by the occurrence of very narrow disconnected though closely parallel bands of a dark-green colour.

The thin section shows the rock to be an augite-syenite-gneiss. It is composed of orthoclase, microperthite, oligoclase and albite, with much smaller quantities of augite, biotite, hornblende, sphene, apatite and iron ore, part of which at least is ilmenite. Some of the individuals of augite are quite fresh but others are partially or completely altered to a dark-green compact strongly pleochroic hornblende.

Nos. 17 and 18.—Robertsville Mine.—Lot 3, Concession IX., Township of Palmerston, Frontenac County.

Specimens from which sections 17 and 18 were made vary from gray (17) to dark greenish-gray (18) according to the abundance of the ferromagnesian constituents. Small veins or dykes of a deep flesh-red mineral (cryptoperthite) are associated with a pale greenish-yellow mineral (epidote). Under the microscope in the section examined (No. 17) the rock seems to be a decomposed diorite composed essentially of plagioclase and hornblende. The plagioclase is sometimes rather fresh, but generally it is more or less turbid due to dust like inclusions in addition to various products of decomposition. The hornblende has a tendency towards the actinolitic habit and a considerable proportion is altered to chlorite. Apatite and sphene are both present in considerable quantity. Pyrite is rather abundant and several individuals of magnetite were noticed. One side of the slide shows a portion of

one of the reddish dykes or veins already mentioned and is made up of cryptoperthite with a smaller amount of plagioclase with yellowish epidote filling up the irregular cracks and interspaces. Microscopic Examinations of rocks.

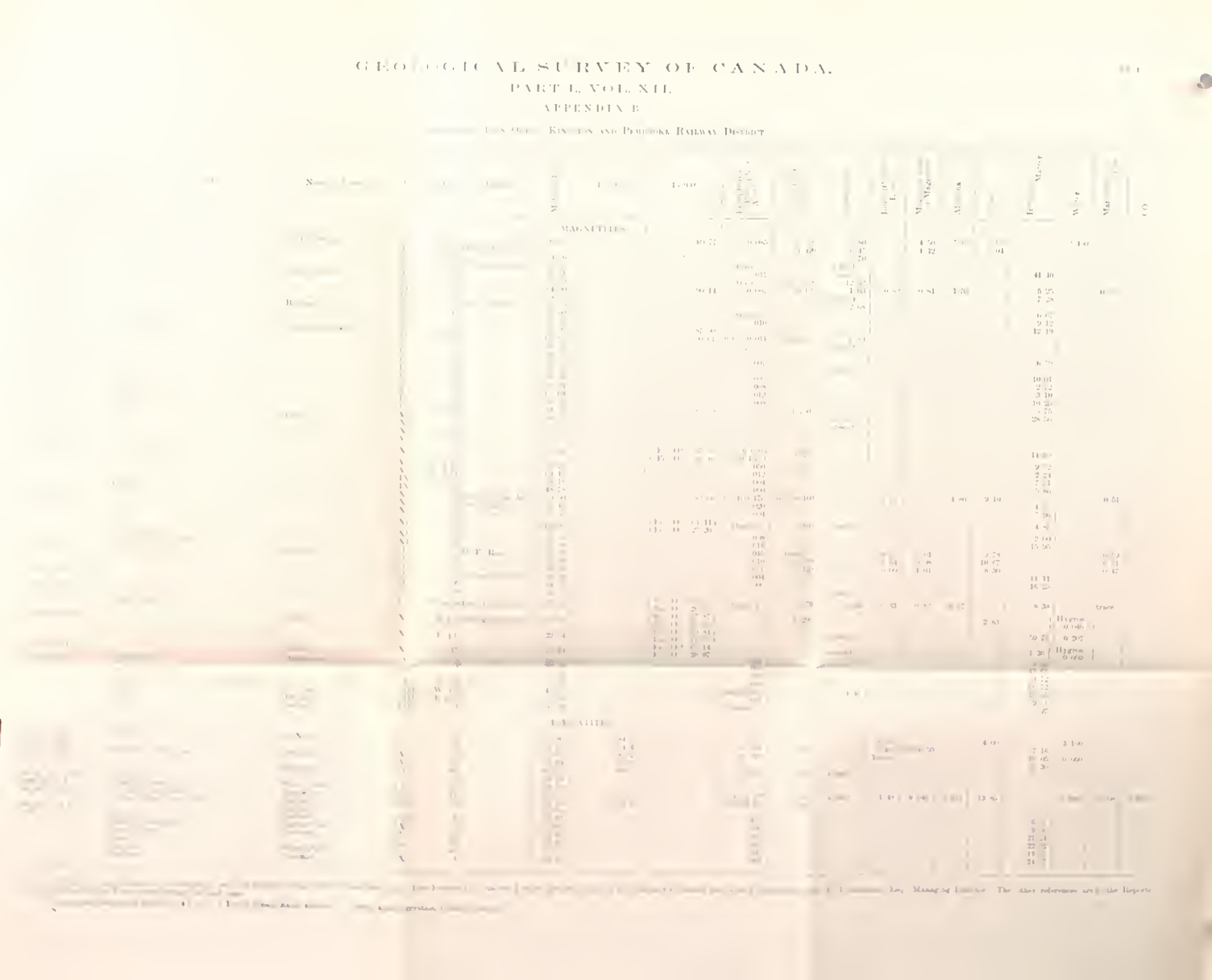
No. 19.—Wilbur Mine.—Lot 4, Concession XII., Lavant Township, Lanark County.

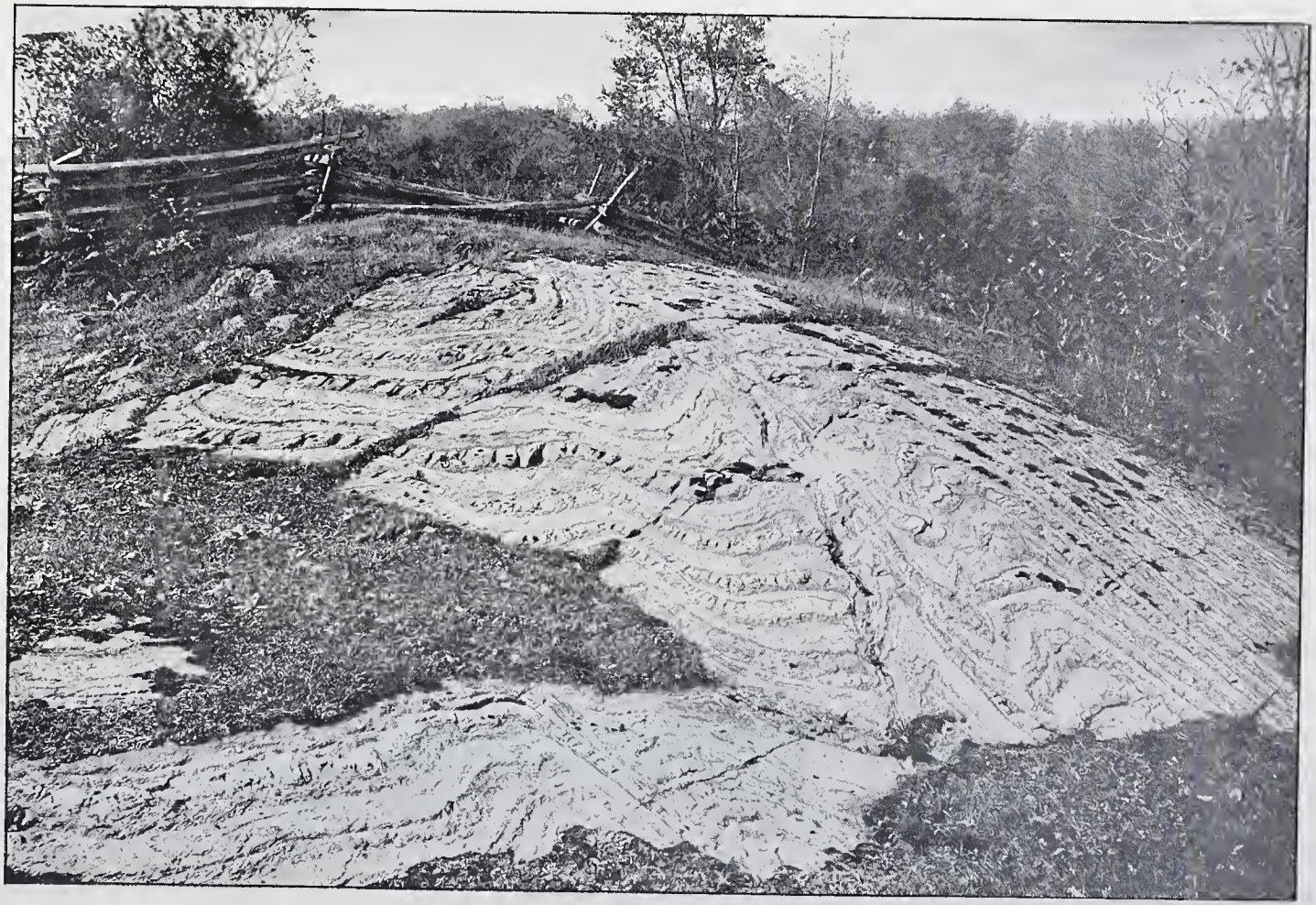
The hand specimen shows a dark reddish gneissic rock. Microscopically the rock is seen to be composed of orthoclase, plagioclase, quartz and biotite with smaller amounts of epidote, sphene, apatite and allanite. It would thus be classified as a biotite-granite-gneiss, or granitite-gneiss.

Nos. 20 and 21.—Yuill Mine.—East half Lot 25, Concession V., Township of Darling, Lanark County.

The hand specimens which represent the ore show a magnetite with a considerable proportion of rocky matter. Section No. 20 is composed almost wholly of magnetite containing numerous irregular fissures and interspaces which are filled with felspar, chlorite and calcite. Section 21 is also largely composed of magnetite, separated by tongues or bands of fine-grained diorite. The magnetite is also full of irregular interspaces which are filled up with hornblende and plagioclase.

LIST OF KINGSTON AND PEMBROKE RAILWAY DISTRICT





CONTORTED GNEISS, NEAR FERRY LANDING, OPPOSITE MONTEBELLO, ALFRED TOWNSHIP PRESCOTT COUNTY ONT.

GEOLOGICAL SURVEY OF CANADA,
ROBERT BELL, M.D., D.Sc., LL.D., F.R.S., DIRECTOR.

REPORT

ON THE

GEOLOGY OF

ARGENTEUIL, OTTAWA AND PART OF PONTIAC COUNTIES,

PROVINCE OF QUEBEC,

AND PORTIONS OF

CARLETON, RUSSELL AND PRESCOTT COUNTIES,

PROVINCE OF ONTARIO,

BY

R. W. ELLS, LL.D., F.R.S.C.

OTTAWA:
PRINTED BY S. E. DAWSON, PRINTER TO THE KING'S MOST EXCELLENT MAJESTY.
1901.

No. 739.

To Robert Bell, M.D., LL.D., F.R.S., &c.,
Director and Deputy Head,
Geological Survey of Canada.

Sir,—I beg to submit herewith a report on the geology, mineral resources and general characters of the country along the Ottawa river and the area adjacent, comprised in map-sheet No. 121 of the Quebec and Ontario series. Much of the work was done several years ago, but delay in publication has arisen owing to the compilation of the map. This has now been prepared, and is ready for the engraver, on a scale of four miles to the inch.

I have the honour to be, sir,
Your obedient servant,

R. W. ELLS.

Ottawa, March 1, 1901.

REPORT

ON THE

GEOLOGY OF

ARGENTEUIL, OTTAWA AND PART OF PONTIAC COUNTIES,

PROVINCE OF QUEBEC,

AND OF PORTIONS OF

CARLETON, RUSSELL AND PRESCOTT COUNTIES,

PROVINCE OF ONTARIO,

BY

R. W. ELLS, LL.D., F.R.S.C.

Area included in report and accompanying map.

The present report embraces the work of several seasons, and relates principally to the areas lying to the north of the Ottawa river, comprised in map-sheet No. 121, of the Ontario and Quebec series. In addition to a large part of the counties of Argenteuil and Ottawa, and Pontiac, it comprises portions of the counties of Carleton, Russell and Prescott, situated to the south of the Ottawa river. This river traverses the southern portion of the map-sheet and furnishes an excellent base-line for observations, as well as affording good facilities for the study of several of the rock formations along its course.

Area described

The area included in the map is not far from 4,000 square miles. It extends from the western limit of the Eastern Townships series, already published, to a line drawn north from a point about ten miles above the city of Ottawa. North of the area included in the map, several lines of exploration were carried on, especially along the upper waters of the principal streams, with the object of better elucidating certain points of structure in the old series of crystalline rocks, the details of which cannot appear on the accompanying map-sheet. A small portion of the eastern half of the sheet has already been published in connection with a report by Dr. F. D. Adams on the structure of certain rock-formations north of Montreal.*

* Annual Report, Geol. Surv. Can., vol. VIII., (N.S.), 1895, part J.

District examined.

In the area north of the Ottawa river an examination was made of the district traversed by the North, Rouge, Nation, Lièvre and Gatineau rivers, and farther west, of the Black and Coulonge rivers, extending to a distance north from the Ottawa of from fifty to one hundred miles. In connection with this, a large amount of exploratory work was done nearly twenty-five years ago by Mr. L. R. Ord, at that time attached to the staff of the Geological Survey, the results of which have never yet been published, but which will be found incorporated in the present report.

Work of Mr. Louis R. Ord.

Former reports on the area.

Several previous reports have appeared on portions of the country, notably by Sir William Logan and Mr. H. G. Vennor. That of Sir William Logan will be found in the Report of Progress for the years 1853-54-55-56. A preliminary report on the area south of the Ottawa was published by Mr. A. Murray in 1852-53. Most of the results of this work will be found summarized in the Geology of Canada, 1863.

Reports by Mr. Vennor.

Mr. Vennor's reports on the area will be found in the annual volume for 1873-74, which had a direct reference to the occurrence of plumbago and apatite in this district, and in that for 1876-77, which also embraced certain points relating to the structural relations of the several division of the crystalline rocks.

Much of the exploration of the area north of the Ottawa had, of necessity, to be conducted by means of canoes, owing to the unsettled character of large portions of the district. Nearer the Ottawa, the country is fairly well opened up by roads and settlements are numerous.

General character of the rocks.

The rocks north of the Ottawa are for the most part confined to the crystallines of the Grenville series and to the Fundamental Gneiss, now regarded as representing the older Laurentian. There are also large areas of granite and other intrusive rocks which are newer than the former division, since they distinctly cut all the members of the series.

Formations along the Ottawa river.

Along the Ottawa river itself, and in the area southward towards the St. Lawrence, the Palæozoic formations have a wide development. They range from the base of the Potsdam sandstone to the top of the Ordovician or Cambro-Silurian system, with occasional outliers of the Medina to the south-east of Ottawa city. These formations are well exposed in the townships of Rigaud, Hawkesbury, L'Orignal, Caledonia, Alfred, Plantagenet, Clarence and Cumberland. Several outcrops of the Grenville series occur in this direction, notably in the township of Alfred, opposite the village of Montebello. At Rockland mills, near the river, there are also indications that the crystalline rocks are not far removed, since the lowest portion of the Potsdam is made up of large

pieces of gneiss and limestone which form a conspicuous feature in the basal portion of that formation at many points.

Rigaud mountain.

In the extreme eastern part of the sheet, Rigaud mountain, a prominent ridge rises a short distance south of the Ottawa and extends for several miles. The mountain is composed largely of granite and porphyry, and is of more recent date than the Calciferous dolomites which appear in close proximity to the west. It is probably contemporaneous with the elevation known as Mount Calvaire, which rises on the north side of the Lake of Two Mountains, and it forms the most westerly of the remarkable chain of eruptive hills which are so conspicuous throughout the area east of Montreal.

Fossiliferous strata.

From the fossiliferous strata, so well seen to the south of the Ottawa, large and characteristic collections of fossils have been from time to time obtained, mainly by one of my assistants, Dr. W. E. Deeks, M.A., and the limits of the several formations have been defined as well as the drift-covered character of a great part of this area would permit.

On the north side of the Ottawa the fossiliferous formations are very limited. East of Ottawa city they are confined principally to a narrow fringe of Potsdam sandstone and Calciferous dolomite, but opposite that city they comprise in addition the Chazy, Black River and Trenton limestones.

In the eastern portion north of the river, the Calciferous dolomites are quite extensively developed between the line of the Canadian Pacific railway and the Ottawa river, extending from Grenville to St. Scholastique, where they are underlaid by the Potsdam sandstone. Along the Grenville canal, and thence along the river to Carillon, the relations of the Calciferous to the Chazy can be well studied. The general distribution of these formations was given on the large map of Canada published in 1866.

Work done by Mr. James Lowe.

The series of explorations begun by Sir William Logan in 1853, was subsequently carried on for some years by Mr. Richardson, and later by Mr. James Lowe, one of his assistants, who surveyed a number of lakes with their connecting waters, more especially those pertaining to the Rouge and Nation systems, the instruments employed being the prismatic compass and Rochon micrometer. These surveys extended northward on the Rouge river to the head waters of the Macaza and the Ruisseau Froid, which are branches of the Rouge from the north-east, crossing the north-western portion of the township of Montcalm. Mr. Lowe also surveyed the main stream of the Rouge northward from

Early surveys.

the end of Logan's surveys to the creek which discharges Big Nomingue lake, from which by a chain of lakes with several short portages, Maskinongé lake is reached. This is one of the largest bodies of water belonging to the Rouge system. In connection with this work also, the chains of lakes on the upper portion of the North Nation were surveyed, including Simon, Whitefish, au Sable, Vert, Long, Sugar-bush, des Isles and a number of smaller sized lakes, the whole forming an extensive series, belonging to the three branches of the Nation. A synopsis of this work will be found in the report for 1863-66, pages 11 to 27, as well as of the work done by the same explorer in the townships of Buckingham and Lochaber.

Report by Mr. James Richardson.

A description of the country along the upper Gatineau from its source to the mouth of the Desert river is given in the Report of Progress for 1870-71, by Mr. James Richardson, in which the presence of several bands of crystalline limestone, associated with gneiss, which is the prevailing rock in this area, is noted.

Exploration by Mr. L. R. Ord.

This river was also traversed by Mr. L. R. Ord, in 1877, in connection with his explorations along the Lièvre, and the chain of lakes between this river and the Gatineau was then also surveyed. Among these are several of large size, including Whitefish and Thirty-one Mile or Grand lake. An examination was also made by Mr. Ord of the Desert river west of the Gatineau and of its principal tributary, the Eagle, as also of the chain of lakes at their head-waters. East of the Gatineau a traverse was made by the same gentleman, of the country between this river and the Lièvre, by way of Baskatong creek and lakes to the height of land which was reached by way of Piskatosin river and lake, the descent to the Lièvre being made by the Tapanee, which enters that stream about ninety-five miles in a direct line north of its junction with the Ottawa near Buckingham. From these examinations, we have a fair knowledge of the country along these portions of the Gatineau and Lièvre rivers. As the results of Mr. Ord's explorations in this district have never been published, and as they contain many points of general interest, both as regards the character of the country and the distribution of the several divisions of the crystalline rocks, they will be given in a subsequent chapter.

Exploration by Dr. R. Bell.

The upper portion of the Gatineau was also descended by Dr. R. Bell, from its source to the mouth of the Desert river in connection with his explorations along the upper Ottawa in 1887. Our own examinations northward ended at this point, so that from all these sources we have now a large amount of available information relating to the structure and resources of this northern area.

Nearer the Ottawa the series of examinations already alluded to as carried on by Mr. Vennor more than twenty-five years ago were somewhat extensive. They included a somewhat detailed study of the formations north of the river in the townships of Templeton, Hull, Buckingham, Portland and Lochaber. The results of much of this work were given in the Reports of Progress for 1873–74 and 1876–77. Examinations were also made by him of a broad stretch of country to the north along the upper Rouge and thence eastward into Morin, embracing a portion of the great area of Anorthosite, subsequently described by Dr. F. D. Adams, in the report for 1895.

Exploration by Mr. H. G. Vennor.

Surveys were also conducted in 1878 in the townships of Buckingham and Lochaber by Mr. Adams, who was then acting as assistant for Mr. Vennor, and later, in 1883, by Mr. J. F. Torrance, more particularly in connection with the apatite deposits of Ottawa county, whose report on the area was published in the Report of Progress for 1882–3–4.

Exploration by Dr. F. D. Adams.

More recently a systematic survey of the important mining areas in the Buckingham district was made by Messrs. E. D. Ingall and James White in 1888–89, and a very excellent and accurate map has been constructed on a scale of forty chains to the inch, which shows the principal topographical features, the position of the various mining locations and the chief geographical divisions. This map has not as yet been issued by the department. A number of valuable papers by Drs. Hunt, Harrington and others, relating principally to the deposits of apatite and plumbago, have appeared at different times. That by Dr. Harrington, on the apatite deposits, is contained in the Report of Progress for 1877–78, while a very valuable paper on the plumbago of the Ottawa district by Dr. Hoffman is contained in the Report for 1876–77. Further notes by the writer of this report, more especially relating to the occurrence of economic minerals in this area will be found in the report on 'Mineral Resources of Quebec,' published in the Annual Volume for 1888–89.

Surveys by Messrs. E. D. Ingall and James White.

Papers by Drs. Harrington and Hunt.

The country north of the Ottawa is intersected by several large rivers and dotted by numerous lakes. Of the former the principal streams more especially connected with the area under discussion, are, beginning with the most easterly, the North, Rouge, North Nation, Lièvre, Gatineau, and further west the Coulonge and the Black.

Character of country north of the Ottawa.

Several of these can be traversed by canoes for distances of nearly 250 miles from their junction with the Ottawa, while by comparatively short portages, the great chains of lakes which lie all over this northern

country, are rendered easy of access. Within the last twenty year also, many colonization roads have been constructed, and by this means large areas, formerly accessible with difficulty, can now be traversed with comparative ease. Along the river Rouge a good carriage road now extends for over one hundred miles, or to a point fifteen miles beyond the mouth of Nominingue creek, while quite recently a line of railway has been completed which connects Montreal with that river at what was once known as Iroquois chute, now Labelle, which is about seventy miles from its mouth. A road has also been made connecting this point with the Jesuit settlement on Big Nominingue lake, and thence down the Nation to the old settlements nearer its mouth. Several other important colonization roads have also been lately made into the hitherto almost unknown country to the west of the Rouge, and a narrow gauge railway has been opened which runs from St. Sauveur, north of St. Jérôme, into the wilderness country to the east of that river about the Sixteen-Island lake, reaching the Rouge in the township of Arundel. The opening of these roads has made a number of areas available, situated among the Laurentian hills, which are underlaid by the limestones of the Grenville series, bands of which, often of considerable extent, occur throughout this portion of the province, and form the sites of some of the most valuable farming lands in the district.

The district along the Rouge river.

The country along the upper Lièvre and Gatineau rivers.

On the Lièvre river settlements extend to beyond the junction of the Kiamika, nearly 100 miles from its mouth, though roads are not yet made for the entire distance. A cross road has, however, recently been opened up to connect this point with the settlements on the upper Rouge, which has also been extended westward to meet the settlements on the upper Gatineau above the mouth of the Desert. The character of much of this upper country is much less hilly than that nearer the Ottawa, and, while large portions are occupied by drift sands, certain areas valuable for purposes of settlement, are already being occupied. Along the Gatineau, roads extend to a considerable distance above the Desert river, and the completion of the railway to this point will render easily accessible a large area of excellent agricultural land. The greater value of this district is due to the fact that a broad belt of crystalline limestone extends northward in this direction for many miles, and, as a consequence, the usually rugged aspect of the granite and gneiss country disappears to a large extent. Much of the country along the Gatineau for nearly a hundred miles from its mouth has been settled for many years. The extension of the line of railway from its present terminus at Labelle on the Rouge across the upper country to the Gatineau will also open up a large tract of

hitherto inaccessible country which promises to furnish large areas of excellent farming land. This agricultural character is often largely due to the presence in places of areas of sandy loam or deposits of sand and clay, which occur, not only along the immediate courses of the principal streams, but also occupy considerable portions of the surface, and out of which the hills of gneiss and granite rise, either in long chains or in isolated masses. This drift character of country pertains to the area fifty to seventy miles inland from the mouth of the several rivers rather than to that along their lower portion, and excellent crops of wheat, oats and potatoes are raised in all the settlements from the Coulonge eastward. The excellence of much of the soil throughout this district is doubtless due to the decay of the calcareous members of the crystalline rocks, which in the country along the several streams, while presenting rarely any continuously widespread development, show their presence often in a series of narrow outcrops, separated by intervals of grayish and reddish gneiss. The greater development of these calcareous rocks along the valley of the Gatineau is seen in the townships of Masham, Cawood, Aldfield, Low, Aylwin, Wright, Bouchette and Maniwaki, adjoining the river on the west, while on the east side they have a very considerable development in the direction of Thirty-one-mile lake and the areas to the north and south.

Agricultural resources.

Crystalline limestone.

In regard to the general physical features of this northern area, it may be remarked that the usually rugged character, seen from the Ottawa valley, to some extent disappears to the northward, so that although there is of necessity a general increase in elevation, there is a greater preponderance of level country. Much of this is occupied with deposits of sand, as in the case of the Kazubazua plains to the west of the Gatineau, but this sandy feature is also distinctly observable over large areas on all the streams from the Rouge westward to Lake Temiscaming. It also appears on the south side of the Ottawa about Pembroke and for many miles to the south and west, in the direction of the Petawawa and on to Chalk river. Much of this drift is a pure siliceous sand, but it is often found to overlie deposits of a stiff blue clay which resemble in character the marine clays of the Ottawa basin, though marine organisms are very rarely visible. These clay-deposits have been noted almost as far north as the height of land between the Ottawa waters and those which fall into James bay, at elevations of fully one thousand feet above the sea-level. On some of the streams, such as the Black river, and on long stretches of the Rouge, the channel for the greater part of its course is cut out of the sand, and rock exposures are rarely seen except when the hills approach the river.

Sandy plains of the Gatineau.

Clay-deposits.

The crystalline rocks.

For convenience of description, the crystalline rocks may be divided into three groups, viz., the gneissic, the calcareous and the massive, the latter being generally intrusive, though in places having a foliated structure. The continuity of these rocks with those which appear to the south of the Ottawa is interrupted by their concealment beneath the broad area of the Palæozoic formations of the lower Ottawa basin, but in the preparation of this report, as the crystallines have by far the greatest development, they will be first considered and the distribution of the fossiliferous sediments will then be given.

Anorthosite rocks.

Report by Dr. F. D. Adams.

In the counties of Argenteuil and Ottawa, while the presence of igneous rocks has been noted at many points, and under different forms, the great bulk of these is found further to the east in the counties of Terrebonne, Montcalm and Joliette. Here a great area of anorthosite, for the most part massive, but in places showing a well-defined foliation, occurs. This area has been carefully studied for some years by Dr. F. D. Adams, and a reference to the character and general distribution of the rocks in this district as then known, is found in the summary report of the Geological Survey for 1887-88, in which he states that, in his opinion, it may be safely concluded that the rocks comprising the principal area of anorthosite referred to, as well as most, if not all the smaller areas, are of eruptive origin.

Early views regarding age of anorthosites

Views of Dr. Selwyn on anorthosites.

The eruptive character of the Labradorite rocks, formerly regarded by Logan and his co-worker as altered sedimentaries and held to constitute the upper division of the Laurentian system, was, however, pointed out by Dr. Selwyn several years before. Thus, in the Geological Report for 1877-78, in discussing the general question of the structure and relations of the Laurentian rocks, he says: 'If it is admitted—which, in view of the usual associations of Labrador felspars, is the most probable supposition—that these anorthosite rocks represent the volcanic and intrusive rocks of the Laurentian period, then also their often massive and irregular, and sometimes bedded character, and their occasionally interrupting and cutting off some of the limestone bands, as described by Sir W. E. Logan, is readily understood by any one who has studied the stratigraphical relations of contemporary volcanic and sedimentary strata of palæozoic, mesozoic, tertiary and recent periods. Chemical and microscopical investigation both seem to point very closely to this as the true explanation of their origin. That they are eruptive rocks, is held by nearly all geologists who have carefully studied their stratigraphical relations. But I am not aware of any one having suggested that they are the products of volcanic action in the Laurentian, or perhaps Lower Huronian epoch;

doubtless as Mr. Leeds says, 'profoundly metamorphosed,' as, of course, they would be from having suffered all the physical accidents which have resulted in producing the associated gneisses, quartzites, dolomites, serpentines and schists.

Dr. Selwyn's report for 1877-78.

'When we recall the names of Dahl, Kerulf and Torrell, in Norway; Maculloch and Geikie, in Scotland; Emmons, Kerr, Hitchcock, Arnold Hague, and others in America; all of whom consider these norites of eruptive origin, we may well pause before accepting Dr. Hunt's conclusions respecting them, and that they should often appear as 'bedded metamorphic rocks' (the opinion expressed respecting those of Skye by Prof. Haughton, of Dublin) is quite as probable as that we should find the mineralogically similar dolerites occurring in dykes and bosses and in vast beds interstratified with ordinary sedimentary deposits of clay, sand, etc., as we do over wide areas in Australia and elsewhere.'

Mr. H. G. Vennor s report, 1879-80

Additional evidence as to the eruptive nature of these anorthosite rocks is found in the summary report by Mr. H. G. Vennor, in the annual volume for 1879–80. Mr. Vennor carefully examined a large area to the north of St. Jérôme in the latter year, and in summing up his conclusions as to the relations of the crystalline limestones of the Grenville series to the associated rocks says, 'In these explorations, perhaps the most important results arrived at were in connection with the bands of crystalline limestone on the western side of the labradorite area, and the junction of these with the great mass of anorthosite rocks already mapped and described by Logan. These limestones, as a whole, appear to be perfectly conformable with the stratified anorthosites, but are occasionally interfered with and disturbed by intrusions (?) of the more massive and granitoid variety of labradorite. This last rock—in which there are no indications of stratification—occupies a very considerable area in the townships of Abercrombie, Howard, Morin, Wexford, Wolfe, Beresford and Doncaster. Its exact outline is not easily ascertained, but I have laid down a provisional line that will indicate sufficiently closely the area occupied by it—some 250 to 300 square miles. .....'And again, in referring to the Trembling lake and Green lake bands of limestone, he says 'there are occasional recurrences of the granitoid labradorite, and many of these exposures have the general appearance of eruptive rocks. One of these masses has been indicated by Logan as occurring in the north-west corner of DeSalaberry, and was here supposed to cover (unconformably) and conceal the further run of the limestone, but we succeeded in tracing this latter continuously around the western side of the former to a connection with the Lake Sam band.'

Relations of the limestones and anortho site rocks.

Dr. Selwyn's conclusions.

In connection with this statement of Vennor's, Dr. Selwyn remarks that 'if the foregoing determinations by Mr. Vennor, which are given in his own words, are correct, they seem very conclusively to prove what I have already stated to be my opinion, viz., that the labradorite or Norian rocks of Hunt do not constitute an unconformable upper Laurentian formation, but occur in part as unstratified intrusive masses, and in part as interstratifications with the orthoclase gneisses, quartzites and limestones of the Laurentian system, as developed in the Grenville region, and mapped by Sir W. Logan.'

Distribution of the anorthosites.

A small portion of map-sheet 121 has recently been published in connection with a report by Dr. Adams* on the anorthosite areas in the country north of St. Jérôme, in the counties of Terrebonne and Montcalm, whence these rocks extend into the county of Argenteuil. In the area embraced in this map, the anorthosite occupies the whole of the township of Beresford and a large part of Wolfe, Howard, Morin and Doncaster. The northern limit of the mass which is a gabbro rather than an anorthosite in certain places, was traced by descending the Devils river, the left branch of which takes its rise in a large lake south of Lac des Baies, near the upper waters of the east branch of the Rouge. Thence, flowing south, it passes several miles to the east of Trembling mountain, and for a part of its course is near the contact between the gneiss and the gabbro which constitutes the rock in the north-western portion of the eruptive area. Along the general line of contact of the anorthosite with the gneiss the latter is frequently deflected from its usual line of strike, as though the gneiss had been pushed to one side by the intrusion, and pegmatite veins are common. This feature is especially well seen where it is in contact with the limestone of the Grenville series as in Morin and Abercrombie, the limestone being abruptly terminated against the eruptive mass. To the west of this, in the county of Argenteuil, true anorthosites are rarely seen, in so far as our observations have extended, but areas of syenite occur in Chatham and Grenville, in portions of which a gabbro character is recognized, and masses of pyroxene in the country more immediately adjacent to the Lièvre and Gatineau rivers may possibly be the equivalent in point of time with the eruptives of the area north of St. Jérôme. Further west along the Ottawa, to the south of Portage du Fort, true anorthosites however occur, and are clearly intrusive in the limestone of the Grenville or Hastings series which has a considerable development in that direction. In addition to these, other rocks such as pegmatite, porphyry, diorites, diabase, &c., are

Their contacts with crystalline limestones.

Syenite of Grenville and Chatham.

Anorthosites of Portage du Fort.

*Annual Report Geol. Surv. Can. vol. VIII., (N.-S.). part J.

found at a number of places, but their distribution and characters will be given in a later chapter.

Logan's report for 1853-56.

The earliest report on the geology of the country north of the Ottawa river, published by Logan, in the Report of Progress for 1853–54–55–56, dealt with the structure and distribution of the Laurentian gneisses and limestones of the townships of Grenville, Chatham, St. Jérôme, &c. In this, particular attention was given to the distribution of the several bands of limestone which are there well displayed, as well as to the occurrence of the syenitic mass of Chatham and Grenville and to the presence of several well defined dykes of greenstone which traverse the area for considerable distances. A second report appeared in 1858, relating principally to the distribution of the limestones and to the drift of the Grenville area, but the results of the work in this district were summed up in the chapter on the Laurentian in the Geology of Canada, 1863. In the opening sentences of this chapter it is stated that 'the rocks which compose the Laurentian mountains were shown by the Geological Survey, in 1846, to consist of a series of metamorphic sedimentary strata underlying the fossiliferous rocks of the province. They are altered to a highly crystalline condition, and are composed of highly felspathic rocks, interstratified with important masses of limestone and quartzite. Great vertical thicknesses of the series are composed of gneiss, containing chiefly orthoclase or potash felspar, while other great portions are destitute of quartz and composed chiefly of a lime soda felspar, varying in composition from andesine to anorthite, and associated with pyroxene or hypersthene. This rock we shall distinguish by the name of anorthosite.'

Early views as to the structure of the Laurentian rocks.

Generally regarded as altered sediments.

All of these rocks, with the exception of the areas of syenite already alluded to were therefore held to be altered sediments, and the anorthosites were regarded as a great altered mass which covered unconformably the gneisses and limestones of the Lower Laurentian, the latter forming the Upper Laurentian series. This view was held for some years to correctly explain the true structure of the system until the later work on the anorthosites, already alluded to, induced a change in opinion as to its true origin. According to the old views, the crystalline limestones occurred at several horizons in the gneiss, no less than four distinct areas of the limestones being recognized, and the whole series of gneiss and limestone was estimated to have a thickness of no less than 22,750 feet of which the volume of the latter division was estimated at 4,770 feet. The thickness of the anorthosite or upper Laurentian member of the series was regarded as doubtful, but was given as 10,000 feet. Several of interesting papers, relating to the

Supposed thickness of the Laurentian, 1863.

structure of these oldest rocks have appeared since the date of the report just referred to, and within the last twenty years there has been a gradual change in opinion on the subject, as the result of much careful and detailed work, both in the field and the laboratory, so that it is now very conclusively established that much of what has been regarded as altered sediments and so described in the earlier reports must now be accepted as altered igneous rock. Under this head must now be placed the greater bulk of the gneissic rocks which form so large a portion of the Laurentian system as well as much of the pyroxenic and feldspathic rocks in which are to be classed the great bulk of the white binary granites, or pegmatites so often associated with the crystalline limestones. These limestones, however, with their associated bands of grayish quartzose gneiss, often very rusty in character, as also well defined beds of whitish quartzite, may readily be assumed as representing true sediments in a very high state of metamorphism, to which may be added certain areas of reddish-gray, and sometimes black gneiss, so that we have, if we consider the whole series under the head of Laurentian, two easily separable portions, viz., an altered igneous and an altered sedimentary series. In this report therefore, wherever practicable, this distinction will be maintained.

Limestones quartzites and rusty gneiss.

THE COUNTRY NORTH OF THE OTTAWA RIVER.

Arrangement of report.

The seven large rivers already mentioned as traversing the country to the north of the Ottawa, divide the district into as many portions. These we propose to describe in order, proceeding from the east to the west, and we will therefore first consider that between the North river and the Rouge river. In this we will first indicate the distribution of the crystalline limestones as assisting very materially in the attempt to depict the structure of the system generally, and the old term 'Grenville series' will be used to indicate the crystalline limestone and associated gneiss, as distinct from the great series of granite-gneisses which underlie them and which may be styled the Fundamental gneiss.

Grenville series and Fundamental gneiss.

Southern limit of the crystalline rocks.

Over the greater part of this area, the rocks are crystalline, their southern limit, north of the Ottawa being defined by a line drawn along the course of the North river from St. Jérôme to Lachûte, and thence in a nearly straight line to Calumet station on the Canadian Pacific railway, two miles east of the Rouge river, on which stream the outcrops terminate at the road crossing just above its mouth. In this distance the crystalline rocks, consisting largely of granite and gneiss

of various kinds, with which, however, are several well defined bands of the Grenville limestones, are directly overlaid by the Potsdam sandstone. The rocks are not continuously exposed, owing to great and wide-spread deposits of clay, which extend to the Ottawa, and out of which outcrops of gneissic granite appear as in the large ridge to the east of the village of St. Andrews; but the characteristic rocks of the Potsdam along with the upper or Calciferous member of the formation appear at a number of points as at Lachute, and several places along the road thence to St. Jérôme, along the south side of the North river. At the former place both these divisions can be readily studied in good outcrops, containing the characteristic fossils of the formation. Nearer the Ottawa river these Calciferous beds are overlaid by the gritty beds of the Chazy, which are well seen along the canal from Grenville to Carillon. To the east of the village of St. Andrews, which is situated near the mouth of the North river, a well defined ridge of reddish granite with a gneissic structure forms a prominent hill feature and is flanked on the south by the Potsdam sandstones, which on the north bank of the Ottawa have an inclination of about twenty degrees. These beds were not, however, seen in direct contact with the granite. On the north side of Jones island, in the Ottawa, to the south of this granite ridge, similar granitic rocks appear, while to the south, on the other side of the river the long ridge of Rigaud mountain rises to an elevation of over 500 feet just to the rear of Rigaud village. This mountain has been described in the report for 1894 as presumably belonging to the same series of eruptive masses which occur in the Eastern Townships, and it is possible that the St. Andrews ridge may belong to the same period. The St. Andrews ridge extends along the north bank of the Ottawa for nearly five miles, with a breadth of from one to three miles. It is separated from the somewhat similar mountain mass of Mount Calvaire, lying to the north of the Lake of Two Mountains but no other rocks are seen in the vicinity of the St. Andrews mass as the covering of clay extends on all sides. Great numbers of anorthosite boulders are found around the flanks of the ridge and across its summit.

Overlaid by Potsdam sandstone.

Lachute.

St. Andrews mountain.

Jones island.

Rigaud mountain.

THE DISTRICT BETWEEN THE ROUGE AND NORTH RIVERS.

The rocks of this area are of special interest from the fact that the first attempts to work out the structure of the Laurentian system was made here nearly fifty years ago, when the area was largely a wilderness. Since that time the country has been opened up by the construction

General character of rocks between the Rouge and North rivers.

of numerous roads, so that the study of the district has been greatly facilitated. The rocks are of very different physical aspects, and presumably of very different ages. Thus in addition to the several varieties of gneiss, which are so conspicuous a feature in all the Archæan country, and which may be regarded as forming the greater portion of the system, there are limestones, both white and crystalline as well as serpentinous and dolomitic quartzites, anorthosites, granites, syenites, porphyries, diabases, augen-gneiss, etc., all of which differ in many respects from the grayish gneiss and the limestone with which they are associated, and most of which, from their field relations, are clearly of more recent date, and of igneous origin as evidenced by their action upon the adjacent strata.

Relations of limestone and underlying gneiss.

In the townships of Chatham, and Chatham Gore, Wentworth, Morin and the Augmentation of Mille Isles, the relations of the limestone and the gneiss can be well studied, as well as the action of these igneous rocks upon both of the former divisions. Starting from Lachute and going northward, along what is known as the West Gore road, the strike is crossed obliquely for some miles. On the north side of the North river, directly opposite the village, the whitish-gray limestone of the series is prominently displayed in a quarry. The outcrop is not large, and consists of two principal bands, the larger of which is exposed for about one mile and a quarter in length, with a breadth on the Gore road of about twenty chains; but the more northerly outcrop is much smaller and is separated from the former by a narrow band of gneiss.

Outcrops north of Lachute.

The general strike of these outcrops is nearly east and west or nearly parallel to the course of the road leading up the North river. The dip on the northern side of the exposure is to the south at an angle of 70°, while on the southern margin, near the forks of the roads it is to the north-west at about the same angle, thus presenting the appearance of a somewhat crumpled synclinal, and the limestone is underlaid by the gneiss on either side. The width of the band diminishes as it is followed to the east and apparently thins out till it entirely disappears before the East Gore road is reached.

Limestones with rusty gneiss inclusions.

In its lower portion the calcareous rock becomes interstratified with grayish rusty gneiss in thin bands, which when they first appear present the aspect of inclusions, some of which are several feet in length and often twisted into serpent-like forms, as if the mass had been subjected to violent disturbing agencies. There is moreover a gradual thickening of the gneissic bands as the lower members of the limestone portion are reached, till the latter entirely disappears, the lower bands of the limestone ranging from ten feet to a foot in thickness.

North of this on the west Gore road, successive exposures of well foliated gneiss occur, reddish and reddish-gray in colour, in places holding disseminated garnets, and with occasional bands of grayish quartzose, micaceous and sometimes hornblendic gneiss, for four miles; in which distance a well defined anticlinal is seen, the rocks on the northern slope dipping to the north west $<50°$-$70°$. A mile further on this is changed to a synclinal, in which, on the property of Mr. Evans, another band of limestone occurs about 150 yards east of the Gore road. The width of the band here exposed is about fifty feet, and the dip is to the south-east $<70°$. This band can be traced northerly on the strike, by occasional outcrops, for several miles, and is probably continuous to the band seen on the road to Lakefield Corner, between concessions III. and IV., Chatham Gore, beyond which to the north, it terminates or is concealed shortly after reaching the next concession. South of Evans' place no trace of this band can be seen, and it cannot be connected directly with that near Lachute, unless on the supposition that it represents that band reproduced in the succeeding synclinal. Scales of graphite occur sparingly throughout a great part of the limestone. but not in quantity to be economically important. Near Lachute this rock has been quite extensively used for lime-burning.

Rocks along the west Gore road.

Graphitic limestone.

The continuation of the West Gore road through Chatham Gore into Morin, reveals the presence of several other bands of limestone. The first of these, north of those just described, is about twenty chains south of the road between concessions III. and IV. of the Gore, where it also presents the aspect of a narrow synclinal band, underlaid by the usual rusty gneiss and quartzite. On the southern edge of this band the dip is N. 10° W. $<65°$ and on the northern edge it is S. 10° E. $<75°$. Further, north on concession V., a band, having an exposed breadth on the road of about ten feet, shows near a brook in the valley to the north of the church at this place, but a short distance east of the church, on the road between concessions IV. and V., it can be traced continuously for more than half a mile, several small bands of rusty gneiss appearing in the mass. The limestones of this area are much distorted, and they seem to terminate abruptly just beyond this point, the country to the east being occupied by foliated granite-gneiss for several miles. Abrupt changes in dip are frequent between the gneiss and the limestone, much of the latter being not far from horizontal while the foliation of the gneiss is often steeply inclined.

Rocks of Morin.

From this last outcrop to the corner of the road through the range Ste. Angelique, Augmentation of Mille Isles, no rocks other than the

Distribution in range Ste. Angelique.

reddish-gray gneiss are visible, the surface being rough and hilly. Just east of the corner indicated, a small exposure of very graphitic limestone, twenty-five feet in breadth, occurs which, however, is terminated directly to the south by a ridge of reddish-granite-gneiss, and the outcrop is concealed to the north by an alluvial flat. At the next fork of the road, three-fourths of a mile further east, a much broader band of the limestone is seen, underlaid on either side by gneiss, the converging dips on the north and south being well defined. The exposed breadth of this band is six chains, the dip of the underlying gneiss on the south being N. 20° W. $<50°$. This band is apparently continuous through Ste. Angelique into range Ste. Marguerite, in an eastward direction along a well defined valley, for a distance of three miles and a half.

Rock formations in Morin township.

Continuing northward into Morin, the country is generally very rugged, but in the valleys of the streams flowing north into Lac des Cedres, two well defined bands of limestone appear, which are traceable northward to the road south-east from Morin post-office towards St. Sauveur, being separated by a prominent ridge of reddish gneiss. Here they turn round the north end of the gneiss ridge and uniting, constitute a broad belt, lying to the east of the Morin Flats road, and the band extends thence in the direction of St. Sauveur for about five miles. In the area to the north of Morin Flats post-office the limestone is penetrated by dykes and masses of anorthosite, already described, and a prominent ridge of this rock also bounds the limestone and associated gneiss to the north and north-east, extending thence to the vicinity of St. Sauveur, whence its outline curves to the north through Abercrombie into the county of Montcalm. The limestone for the most part follows the depressions between the mountains of this district; and, leaving the township of Morin, continues in a band nearly a mile in width, eastward to the village of St. Sauveur, where its outcrop bends abruptly to the north and abuts directly against the mass of anorthosite just described.

Limestone of St. Sauveur.

Of the several limestone areas in this vicinity, that of Morin and St. Sauveur is the most extensive. The bands all run in a direction approximately east-north-east, and from the strikes and dips of the calcareous portion as well as of the underlying associated gneiss and quartzite, together with the great similarity of the rocks throughout the entire area, it would appear that they all represent portions of the same mass repeated by successive foldings so that the several outcrops of limestone may be parts of one and the same band.

Irregular outcrops.

Many of these outcrops are quite limited, presenting the aspect of narrow bands, which extend for a few hundred yards, or in places for

only a few feet and then disappear, while others can be followed on their strike along the valleys of the streams for several miles with only occasional gaps in the exposures where they are concealed by the drift.

Lachute to St. Jérôme.

East of Lachute, on the road leading to St. Jérôme, along the north side of the North river, the limestone of the Lachute area can be traced nearly to the East Gore road which leads to Lakefield, when it apparently ends; but on the river road, about one mile and a half east of this corner, a narrow band of only a few feet in thickness appears in a cliff of granite-gneiss. This can be traced north-eastward for about twenty chains as a band in the gneiss, when it also ends and no further indication of it is seen. Thence to the vicinity of St. Jérôme the gneiss is strongly granitic in character, but about half a mile west of the bridge at this place a narrow band comes in which is traceable in occasional outcrops for a little more than a mile northward. Between St. Jérôme and St. Sauveur the rocks are mostly gneissic granites, with a well marked foliation, but two well defined bands of limestone appear in Mille Isles which are the eastward extension of those noticed to the north of Chatham Gore.

Lachute to Lakefield.

On the road from Lachute to Lakefield, East Gore road, a very narrow band appears about one mile and a half to the south of the latter village and is exposed at intervals for two hundred yards, when it disappears; but further south, about one mile south of Sir Johns lake, on the Belslamb farm, along the stream flowing thence to the North river, another small and irregular outcrop, flanked by reddish granite is seen. The limestone here is very impure with many inclusions of rusty gneiss and quartzite, giving it the aspect of a coarse conglomerate. It is here exposed for about 300 yards, the western margin being concealed by clay. No trace of this limestone was observed at Sir Johns lake to the north, the rocks there being reddish and yellowish-gray gneiss. It is certainly not continuous with that noted on the road to Lakefield. Still further south another small outcrop is seen about half a mile east of the East Gore road and the same distance north of the point where it joins the river road. This is also associated with reddish-gray gneiss. Throughout the greater part of this area the gneiss and limestone dip at angles of 50 to 90 degrees, and opposing dips are frequent, showing that the whole series is thrown into a number of folds, while in places the rocks appear to be overturned. In most of the limestone, scales of graphite are common, but no other minerals of importance were recognized.

East Gore road.

Graphitic limestones.

Foliated gneiss.

The greater part of the gneiss in this area belongs to the foliated variety, and may possibly represent what has been designated as the Fundamental Gneiss. In parts, however, masses of granite are seen.

Limestones of Chatham, Wentworth and Grenville.

In the townships of Chatham, Wentworth and Grenville several important bands of the limestone occur. Of these probably the most easterly is that of which the southern extremity is seen near Dalesville, on lot 11, range IX. of Chatham. From this point the band can be traced northward along the valley of Big creek, entering the township of Wentworth on lot 9, range I., and thence bending north-east, reaches the line of Chatham Gore in range V. The breadth of this band in Wentworth is 700 yards. On the road west of Dalesville two other bands of limestone occur in synclinals in the grayish and reddish-gray gneiss, east of the great mass of syenite which occupies the western part of the township, but these are of limited extent. Another band comes in on the southern end of Lake Louisa and occupies the end of a point. On its extension to the north-east it is seen in two small islands in the lake, but was not recognized at the north end, while from the south end it can be traced for one mile, when it disappears. On the west shore of the lake the underlying gneiss is seen, and on the road from this place to the village of St. Jean two other bands occur. The most easterly of these is of small extent, but the other continues along the valley of the creek at this place to the mass of syenite on range X., Chatham, by which it is cut off. At the northern outcrop this band divides into two parts, one curving north-westerly along the road to St. Jean church but soon ending in this direction. A repetition of this band is seen several hundred yards to the west, separated from the former by a ridge of gneiss, the outcrop being only local; while half a mile further west another small exposure is seen in a road cutting, but this cannot be traced in either direction. The strike in this area changes from north-east to north-west, being apparently diverted by the intrusive mass of syenite. Beyond this, however, it gradually swings round, near the line between Wentworth and Harrington, to its usual north-east direction. Here a small band of limestone, beginning near Spectacle lake, can be traced almost continuously for more than ten miles and probably reaches Lake Sapin in the township of Montcalm. It is crossed by the new road from Lost river to Morin, and has a strike at that point of nearly north and south. The band is of no great breadth and is partially concealed along a chain of lakes in this direction. One mile west of this band the limestone of Sixteen Island lake is seen and this can be traced for nearly twenty miles. This band forms a sigmoid curve. Its southern end abuts against the mass of the Grenville syenite, whence it appears in frequent outcrops along the road leading from Dalesville to Lost river. At this point it crosses the road and continues easward along the chain of lakes comprising Gate, Fraser, Long, Silver and Sixteen Island where the band

Lake Louisa.

Village of St. Jean.

The Spectacle lake band.

Sixteen Island lake.

Lost river Lands.

rapidly narrows, appearing in two small islands in the lake, and the underlying quartzite band has a considerable development. At the northern end a very narrow band can be traced at intervals into Proctors lake, where it has an exposed thickness of not more than twenty feet, and here it apparently ends. At Lost river, Long and Gate lakes, this band is divided into two parts by a ridge of reddish gneiss, the northern portion terminating westward a short distance west of the road leading to Arundel, near the south end of Big lake. A well defined synclinal structure is visible in the main band at several points in its course. It is underlain by the usual grayish quartzose and rusty gneiss, and its lower portion contains twisted inclusions and small bands of the latter. On the south side of Silver lake, a portion of the band is serpentinous and a small development of asbestus (chrysotile) in veins up to half an inch in thickness is seen. The quantity, however, is too small to be of much economic importance. This is on lot 20, range IX., Wentworth. The limestone at this place dips N. 55° W. < 50°. Masses of white weathering rock, composed of quartz and felspar, a binary granite or pegmatite, occur in the vicinity. Near Sixteen Island lake pyroxenic rocks come in and small crystals of mica occur on the south margin of the band where the dykes of white granite are found in place, and on the west half lot 23, range VII., Wentworth, also in the same rock, scattered crystals of mica and apatite are found with idocrase. On lot 22 of the same range, small quantities of graphite occur in vein form as well as in disseminated scales in the limestone, but the quantity of the mineral is not such as to be of economic value. The northern margin of this band has a regular dip to the south, showing its synclinal character

Synclinal structure.

Chrysotile.

Pyroxene, mica and Idocrase.

The road from Grenville northward, after traversing the townships of Grenville, Harrington and Arundel, reaches the Rouge river in De Salaberry, near the crossing of the county line between Ottawa and Argenteuil. Thence it closely follows the valley of the stream for nearly sixty miles to the head of the settlement on the river. For a large part of this distance the road crosses obliquely the strike of the rocks which present a succession of outcrops of gneiss of various kinds, with occasional bands of limestone. That portion of the road between Grenville and Lost river, a distance of twenty miles, passes over no less than seven distinct bands of the calcareous rocks, which, however, are possibly repetitions of the same one.

Grenville to Lost river.

In some of these, converging dips indicating a synclinal structure, are well seen, but at certain points the series presents the aspect of an overturned anticlinal. The gneiss and limestone are for the most part

Synclinal structures in limestones.

inclined at high angles, and the structure is complicated by the presence of the western portion of the Grenville and Chatham syenite mass. The usual strike of the rocks is from N. 10° to 30° E. On a road approximately parallel to this, leading north from a point on the shore road three-fourths of a mile east of Calumet station, and which meets the Grenville road in the northern part of range VII., similar bands of limestone occur, some of which are probably the equivalents of those noted on the road from Grenville to Lost river. Some of these outcrops are, however, very local, and can be traced for only a short distance, having an exposed surface of but a few feet; while others have a breadth of several yards across the strike. Considerable areas are covered by sand and clay, so that the entire extent of the deposits is not, in all cases, visible. On the road north from Calumet, four bands are crossed, separated by areas of generally grayish and rusty gneiss.

Road north of Calumet.

Calumet station and vicinity.

On the southern face of the hill at Calumet station, on the Canadian Pacific railway, there is also an exposure of the limestone which has a north-easterly course and which extends westward to the railway at the crossing of the Calumet river. It dips to the south-east and is underlaid by heavy beds of white quartzite, which in turn rest upon reddish-gray quartzose gneiss. The north-east strike of this limestone band would carry it to an outcrop on the road just mentioned, where on the south side of the exposure the dip is to the north-west, thus showing a synclinal structure in this area. An interesting outcrop of the limestone is also seen on the Mountain road and on a cross road leading thence easterly to Glen road. Here the rock forms a pronounced ridge of twenty feet in height, and contains, in addition to the usual inclusions of rusty gneiss, common to most of the calcareous rocks of the Grenville area, numerous well-rounded pebbles of gneiss and quartz-rock, thickly scattered through the mass. The lines of stratification are also well defined, so that the whole presents much of the aspect of a conglomerate. It is underlaid to the north and west by quartzose and rusty gneiss, which in turn rests upon the reddish-gray gneiss of the usual type.

Conglomerate near Calumet.

It will thus be seen that of the several limestone bands exposed along the roads north from Grenville and Calumet, synclinal structures are visible in most cases, though the lack of good exposures interferes with the attempt to establish this fact in every outcrop. Of the most important band, or that which crosses near Lost river, and continues easterly to Sixteen Island lake, the synclinal character is clearly evident at several points. The limestone at this lake on its southern margin, rests upon grayish quartzite, having a dip to the north-west of 45 degrees, but on a small island one mile to the north, a similar rock

Rocks of Sixteen Island lake.

LIMESTONE CONGLOMERATE (?), ON CROSS ROAD, LOT 17, RANGE IV., GRENVILLE TOWNSHIP, ARGENTEUIL CO., P.Q.

in continuation of this band has a reverse dip to the south-east at an angle of 50 degrees, while a similar structure is seen near the Lost river road crossing. A high ridge of reddish gneiss extends along the east side of this lake and separates it from the band already described as passing parallel to this about a mile to the east.

Lost river.

The name of Lost river is given to this stream from the fact that it passes beneath a ledge of limestone which divides the waters of Gate lake from Fraser lake, about two miles east of the road that extends to Arundel. The stream is here conccaled for about one hundred feet. Several other cases of these underground streams are known in the limestone areas north of the Ottawa.

Lost river to Arundel.

From Lost river northward, to Arundel, following the main road, two principal bands are crossed, of which the first has a somewhat extensive development along the east shore of Big lake or Johnson lake, into the upper end of which the Lost river flows. This Big lake band apparently terminates a short distance south of the lake, but to the northward continues along the valley of the stream to Bevan lake. The breadth of this band on ranges VII. and VIII., Harrington, is nearly one mile, and it includes a large part of lots 7, 8 and 9. At the termination on Bevan lake the band becomes very much smaller and is underlaid by the usual series of gray and rusty gneiss with converging dips on either side of the outcrop. On the east side of the band the dip is west at an angle of 85 degrees. A repetition of this band is seen on the south-west side of this lake, separated from that just described by the usual ridge of reddish gneiss. In this second band, which extends to the south of the lake for over two miles, where it ends, the converging dips to the centre are also seen. The band has a breadth of three-fourths of a mile, where it meets the lake, and what may be its continuation appears on the eastern margin and extends for several miles north-easterly till it also disappears to the south of the great foliated granite gneiss area of Bark lake.

Bevan lake.

Bark lake.

Big lake band of limestone.

The Big lake band, while apparently terminated not far from the upper end of the lake by a great mass of reddish granitic gneiss, is on the direct strike southward of another important band which crosses from Harrington into Grenville on lots 14 and 15 of Harrington. From this point its breadth diminishes, but is apparently indicated by an outcrop on the Rouge river, about one mile below the Bell chute portage or about on lot 26, range IX., Grenville, from which its continuation can be traced by very good exposures to the Canadian Pacific railway near Pointe au Chêne station. If these several outcrops are parts of one band, which seems probable, it would have a total length

of over twenty miles and be probably the most extensive in the whole area. To the west of this band another comes into view on the Rouge river, on lot 17, range V., Harrington, which continues south-west for four miles to the north line of the township of Grenville. It appears on the Rouge in an irregular and impure outcrop, much mixed with irregular pieces of the rusty gneiss at the foot of the portage past the Bell chute, with a breadth of only a few feet, whence it extends south-west into the augmentation of Grenville for several miles, terminating apparently on range VII. Still further west at the distance of a mile, a smaller band parallel to the last, begins on range V., of Harrington, and crosses the lower part of the Maskinongé river, a short distance above its junction with the Rouge. This is well seen on the latter stream at the Marble falls, as well as in small exposures along the road leading down to Lake Commandant, a short distance below the bridge over the Rouge at the south line of the township. This portion of the band is small and chiefly of importance as serving to indicate the structure of this part of the area.

Limestones of Harrington township.

Marble falls.

North of the township of Arundel and east of the Rouge, the calcareous members of the system are but sparingly seen. At St. Jovite, in the township of DeSalaberry, a band occurs which has an exposed breadth of 250 yards, inclosed between nearly vertical walls of gray quartzite and gneiss, the latter presenting the usual rusty characters at the contact with the limestone. The outcrop can be traced for several hundred yards till it is concealed by a mantle of clay and sand; but a thin irregular band appears at intervals along the valley of the Devils river, and on its branch which issues from Trembling lake, which may indicate its extension in this direction, though its regular strike is deflected by some of the masses of intrusive granite-gneiss which are seen in the vicinity. At the outlet of the lake this band has a breadth of not more than fifty feet, but northward it can be traced on several of the small islands near the centre and northern end where the strike changes from its usual north course and bends to the west. Here it apparently terminates against a great mass of granite-gneiss which rises boldly on the west side of the lake. This band of limestone also has a synclinal structure with converging dips on either side towards the centre of the lake. This is the celebrated Trembling lake band, which in the Geology of Canada, 1863, was regarded as the lowest of the limestone series in the Laurentian system, and which by some error in delineation was made to extend northward into Lac les Grues. A careful examination of the district, however, shows that it does not follow this course, since all the rocks about the northern end of this lake are of the gneissic and granitic variety,

Country north of Arundel to Trembling lake.

The Trembling lake limestone.

Granite of Trembling lake.

similar to those seen in the mass of Trembling mountain. The only depression in this direction is along the valley of Caché creek, which discharges the waters of Lac les Grues on which the gneiss appears and no trace of the limestone was here observed.

Trembling mountain.

Trembling mountain rises above the east shore of the lake to an elevation of 1,720 feet by aneroid and consists, for the most part, of moderately fine-grained reddish-gray gneiss with bands of black hornblendic gneiss, the strike of the foliation being N. 20° W. with a dip to the west. From a calculation of several measurements the elevation of the summit of Trembling mountain is not far from 2,500 feet above sea-level. To the north and north-east of this mountain the rocks are all granite-gneiss and this rock extends to the east as far as the Devils river, where it meets the great mass of the gabbro and anorthosite described by Dr. Adams in the Report for 1895, vol. VIII.

Route from Trembling lake to Labelle on the Rouge.

Between Trembling lake and the Iroquois chute (now Labelle) on the Rouge, three lakes are crossed, there being four portages on the route. On the first, Great Beaver lake, the rocks are all granite and gneiss, most of which is foliated, but large portions massive and syenitic in character, which form great hills to the east and extend across to the west shore of Trembling lake. Crossing a short portage, Long lake is reached, where the rock shows a more decided banding and is in places well stratified with hornblendic and garnetiferous bands, but as a whole is of the reddish variety. Here a small band of grayish binary granite comes in, and a thin outcrop of calcareous rock occurs near the north end of the lake, but no well defined limestone is visible. A portage of a few rods in length connects with Lac Vert, on which the rock is all reddish and reddish-gray gneiss, and similar rock continues thence to Iroquois chute, about one mile distant.

Labelle north to the Macaza river.

At this place reddish-gray gneiss appears at the bridge with a strike of nearly north and a vertical foliation. Just above the village, well banded grayish and garnetiferous and sometimes rusty gneiss strikes north and south and dips west $< 85°$ and this can also be seen on the north side of the river, whence a succession of gneisses red, gray, black, sometimes garnetiferous, can be traced to the forks of the Rouge and the Three Arms river, the latter stream soon dividing into the Macaza, the Ruisseau Froid and the Chaud.

Rapid des Pins.

In order to determine the limits, if possible of the limestones in this direction, an examination of these upper waters of the Rouge was made. The only outcrop of the calcareous member on the Rouge between the Labelle and the forks was seen at the Rapid des Pins about

five miles above the village, where a band from three to five feet in breadth is exposed. This is underlain by quartzite, and what is probably the continuation of the same band, with a width of only two feet of limestone, appears just below the mouth of the Macaza associated with twisted gneiss and quartzite. The rocks along this stream strike north and several reverse dips both to the east and west are seen, generally at high angles.

The Macaza and its branches.

The ascent of these branches of the Rouge showed that the prevailing rock in this direction was reddish gneiss, chiefly of the granitic type. The limestone bands seem to disappear almost entirely, as well as the associated grayish gneiss and quartzite. On a small island near the head of Lac Chaud a small outcrop of very impure limestone was noted, which was filled with inclusions and pebbles of rusty gneiss and a small outcrop of two feet in thickness appears on the eastern shore of the lake which apparently marks the northern limit of the calcareous member in this direction, the rocks thence northward being all of the gneissic variety. The elevation of this lake is not far from 1,000 feet above the sea. From these observations it would appear that the calcareous portion of this system occupies a central position in a broad basin-shaped area with a depression to the south, and the extent of the limestone bands which have a very considerable development near the Ottawa, gradually diminishes to the northward, till at a certain elevation they disappear entirely.

Limestones die out.

Outcrops near St. Jovite.

The only other observed outcrops of limestone to the east of the Rouge, were in DeSalaberry township. About two miles to the south of St. Jovite, near the forks of the road to the ferry over Devils river a small ledge is exposed resting upon reddish gneiss, and this can be traced northward to Maskinongé (Pike) lake where it shows on the main road to St. Jovite and also on the road along the north side of the lake. The limestone contains scattered crystals of pyroxene and apatite and was reported to carry asbestus, but a careful search failed to discover any of this mineral.

St. Jovite to St. Faustin.

East of St. Jovite, on the road to St. Faustin, a small outcrop of the limestone is indicated presumably by the presence of scattered blocks of the rock, but the band is seen in place both to the north and south of the road. The quantity, however, is small and it is probably a repetition of that near St. Jovite.

Annunciation village.

The most northerly outcrop in this area near the Rouge was noted in an old quarry, about one mile south of the village of Annunciation, in the western part of the township of Marchand. This place is 600

yards north-west of the road leading from that village to the east side of the Big Nominingue lake. Portions of the rock are serpentinous, but the greater part is of excellent quality for lime-burning. In the serpentinous portion Eozoon structure was observed near the contact with a mass of reddish syenite-gneiss. Eozoon structure.

The rocks along the upper part of the Rouge to the Nominingue creek, as also around the shores of the Nominingue lakes, are all gneissic granites. No trace of the limestone formation, other than those mentioned was observed. The strike of the gneiss is for the most part north-east, the dip sometimes to the east and at places to the west, showing a folded structure. From these lakes a road extends southward along the course of the Nation river to the Ottawa river, and settlements are beginning to form in this direction. Nominingue lakes.

A traverse was made of the several lakes and portages which extend from the Big Nominingue lake to the Rouge river, the geological features of which will be given in the next chapter.

The Rouge river takes its rise near the height of land, separating its waters from those of the west branch of the St. Maurice, and after a course of about 150 miles joins the Ottawa two miles west of Calumet station on the Canadian Pacific railway. The principal branches from the east are the river of Three Arms, which divides into the Macaza and the Ruisseaux Chaud and Froid, already referred to, and which enters the Rouge about eight miles above the village of Labelle in the township of Marchand. The next considerable stream from the east is the Devils river, which rises near one of the branches of the Mattawin, after draining numerous lakes among which the most important is a large lake south-west of Lac des Baies at the head of the west branch and unnamed. Continuing southward, several miles to the east of Trembling mountain, it receives the waters of Trembling lake and others of that chain by a short creek and empties into the Rouge in the north-west corner of Arundel. Further to the south the Lost river enters the main stream near the middle of the same township, and discharges the water of a number of lakes often of good size, among which are Bark, Bevans, Big and Sixteen island, with others of the chain. The Rouge river and its tributaries. The Devils river. The Lost river.

From the west the principal tributaries are Nominingue creek, discharging Big and Little Nominingue lakes and the extensive chain in connection with these, and the Maskinongé river which takes its rise near the Nominingue lake, and after a long course on which a number of large lakes are found, enters the Rouge in the south-west part Nominingue creek.

Maskinongé river and lake.

of Harrington. On this stream is Maskinongé lake, nearly ten miles long. Numerous smaller streams abound, but those mentioned are the principal and the only ones traversable by canoes.

The Rouge below Labelle

As already mentioned, good wagon-roads now exist on either side of the river, and extend northward for nearly a hundred miles from its mouth, the most inland village being Charbonneau, which is about thirteen miles above the mouth of Nominingue creek. Descending the river from Labelle, (formerly Iroquois chute) which is the present terminus of the railway, 101 miles north-west of Montreal, and one of the most important villages in this section of the country, the banks are largely composed of sand and clay, principally the former, which extends to within twenty-five miles of the mouth, where the sand is replaced by clay in the river valley.

Limestones of Three Mountains lake.

At the mouth of George creek, which enters the Rouge about seven miles below Labelle and discharges the waters of the Lake of the Three Mountains, a band of limestone comes in which follows the valley of this creek and which is probably an extension of a small band seen at the outlet of a small lake to the north of the Three Mountains lake. From the mouth of George creek the lime stone can be traced down the river in a series of exposures to Conception village, and thence, though sometimes concealed by drift, to the road at the ferry turning off to the Devils river in the west part of range III., de Salaberry. On this cross road it continues for about a mile, when the exposures disappear. Another small band occurs on the road leading across to the Rouge river from St. Jovite along the south shore of a narrow lake which has a strike nearly east-and-west, but which, after passing the west end of the lake, turns northward again in the direction of Crescent lake to the east of Conception village. This band does not continue very far in this direction and the deflection in its strike is apparently due to the presence of a large mass of augen-gneiss which extends thence northward to Lake Sam on the road from St. Jovite to Labelle.

St. Jovite to Rouge river.

The Green lake band.

Continuing down the Rouge, about one mile north of Huckleberry chute, a small band appears on the west bank of the river and strikes north-west in the direction of Green lake, which lies to the south of Three Mountain lake and is probably the southern end of the Green lake band. This does not appear on the shore of Three Mountain lake, but keeps to the south of it. A band seen on Muskrat lake, which lies between the latter and Lake Maskinongé, and on several small lakes to the south, may be the extension northward of this outcrop, though it cannot be traced continuously, owing to the difficult character of the country to be traversed.

At Huckleberry chute, two bands are exposed, separated by a seven foot band of gneiss. The limestones have a breadth of six feet and twenty feet respectively, and there appears to be an anticlinal structure at this place. A third band, with a thickness of forty yards comes in on the west, mixed with gneiss, but these bands can not be traced to any distance below the chute, as the only exposures in this direction are of reddish-gray gneiss. Huckleberry chute.

From this point down to the bridge over the river at the Jesuit settlement in Arundel, no calcareous rocks appear along the stream. Occasional outcrops of the gneiss are seen, but the banks are frequently occupied by sands which overlie the clay. At the Arundel bridge masses of reddish hornblendic syenite rock are exposed, but a short distance above this, a band of limestone, associated with grayish and rusty gneiss is seen in the river. Drift conceals the rocks for a mile or so below, but what is apparently a continuation of the same band is seen on the road down the east side in a small outcrop on the line between ranges I. and II., Arundel, below which nothing is visible above the drift till the head of Mountain chute is reached. A small band appears, however, at Dog chute, one mile below Dog rapid, in the northern part of Harrington, which has a strike of N. 50° W. The dip is vertical and may represent the northern extension of the band seen at Mountain chute. The associated rock is a grayish rusty gneiss. Dog chute.

The bands of limestone in the area adjoining the lower portion of the Rouge have already been described. For the last seven miles of its course, the river flows over reddish and reddish-gray gneiss, which forms a high range of hills along the east bank and along which a good section can be observed. The strike is, for the most part, N. 30° E. and the dip is to the north-west $<70°$. The last three miles of the stream, from the head of the Nigger rapids, are impassable for canoes on account of falls and broken water, and the road thence, passes over a ridge of gneissic granite. There is a narrow band of limestone near the summit. Further to south another band is seen along the road across the crest of the hill overlooking the Ottawa, and a third narrow band appears on the slope descending to the railway and about three-eighths of a mile north of the track. The last is associated with granitic rocks. Rocks along the lower Rouge river.

It will be seen therefore from the descriptions given, which have been stated in detail on account of their importance in elucidating the structure of this area, on which the characters of the Laurentian were originally based, that the outcrops of limestone are quite numerous,

Irregular distribution of the several outcrops.

but for the most part of no great extent. It was found impossible to trace many of them continuously to any great distance, for though some of the largest deposits could be followed for several miles by occasional outcrops and by the character of the soil, even these often showed great irregularity, rapidly changing their character by decreasing in breadth or by abrupt ending. In many places the exposures are concealed by drift so that it is impossible to trace them; at others the areas were clearly very limited and their extent could be easily ascertained. While the general strike of the gneiss and associated limestone is from ten to twenty degrees east of north, this sometimes rapidly changes in direction. In such cases masses of granite, anorthosite or augen-gneiss are usually found in the immediate vicinity. Good illustrations of this divergence are found in Grenville and Chatham near the syenite of that district, as well as on the upper Rouge near Three Mountain lake. In Morin also sudden changes in the strike are noticed, due to the anorthosite, as also in Grandison and Clyde townships, where great masses of syenitic gneiss and augen-gneiss are present. In these cases the limestone bands, after passing the intrusive masses gradually tend to resume their normal strike, unless they are entirely cut off as is sometimes the case.

THE AREA BETWEEN THE ROUGE AND NATION RIVERS.

Area between the Rouge and Nation rivers.

This area differs from the preceding in that the surface is more largely occupied by lakes, some of which are of considerable size. While a great part of it is as yet unopened to settlement, it is readily traversed by canoes. The western part of the seigneury of Petite Nation and the townships of Ponsonby and Suffolk on the north, are intersected by roads; while along the valley of the North Nation, a colonization road, already referred to, extends to Nominingue lake on the waters of the upper Rouge, a distance in a straight line of nearly sixty miles.

Colonization roads.

Two colonization roads extend west from the Rouge into this area, the most northerly of which turns off from that stream about three miles above the village of Labelle and continues west to the Big Nominingue, meeting that from Annunciation, on the shore of the lake; the other starting near the same point trends south to the lower end of Maskinongé lake, and then continues to Desert lake and on to the new settlement of Chapleau, where areas of good land exist,

Big Nominingue lake.

underlain by crystalline limestone. Around the shores of Big Nominingue lake the only rocks observed were grayish, reddish-gray and

hornblende gneiss, striking ten to sixty degrees north of east and showing by reverse dips, at several points, the presence of anticlinal structure. The eastern shore shows no ledges, the beach being boulder-strewn; but hills of reddish-gray gneiss and granite rise a short distance from the water. The road from Annunciation, past the east shore of this lake, crosses at the Narrows which connects with Little Nominingue lake, and extends to the Jesuit settlement, which is half a mile from the south-west angle of Big lake. Along this road outcrops of gneissic rocks are frequent. The west shore of the lake shows similar rocky ledges at several places, which strike generally north and south and dip to the west. The southern end is sandy as is also the northern shore for some distance back, being probably the extension of the drift plains of the upper Rouge. No trace of limestone appears on the shores of this lake. The north shore of Little Nominingue lake, about one mile to the south, is also low and sandy to the mouth of Sauge creek which discharges the waters of a chain of lakes from the north. A road extends along the south shore of this lake connecting with that leading to the Nation, and several settlers have already located there. The land both to the south and west appears to be of good quality and comparatively free from stones. On the east side of Sauge creek a high cliff of grayish hornblende gneiss occurs, with a dip S. E. $< 25°$ and extends along the north side of Big lake to the east end. Here several small islands are found, on one of which a small irregular band of limestone, very impure with inclusions of rusty gneiss, is seen. The structure of the limestone band is a crumpled synclinal, the underlying rocks on either side being rusty gray gneiss and quartzite.

Little Nominingue lake.

Impure limestones.

From Little Nominingue lake a portage of sixty chains leads to Blanche lake, which is the head of the east branch of the Nominingue river. The shores are low and no ledges visible. From this a portage of about the same length leads to Black lake, at the head of the east branch of the Nation river, around which also the country is low, but gneiss hills rise at a short distance on either side. A portage of a mile leads thence to Little Black lake, where reddish gneiss appears, but no limestone is seen in this direction. Thence by a portage of a mile and a half, a small lake is reached which is half a mile west of Désert lake, the head of the west branch of the Maskinongé river. Reddish-gray and hornblendic gneiss occurs about these lakes, but on a point on Désert lake, separating the two bays at the north end, limestone is seen, underlain by quartzite and rusty gneiss. The dip is S. 55° E. $< 50°$. At the outlet of this lake, which is to the south grayish garnetiferous hornblende gneiss strikes S. 20° to 75° E. The

Portage route from Little Nominingue to Maskinongé lake.

Désert lake.

shores of most of these lakes are densely wooded with spruce and cedar, and rock outcrops are few, while most of the surrounding country is also a thick forest.

From Désert lake south, a chain of lakes including Long Point, Mauve and Trout, is traversed before reaching Maskinongé lake. On the first of these only is the limestone well seen, large outcrops appearing on lots 4 to 7, range VI. and VII., township of Minerve, occupying a synclinal on the west shore of the lake and this is probably continuous southward to Lac Vert (Green lake). Several folds are seen along this part of the lake, while the rest of the shore shows ledges of reddish gray and garnetiferous gneiss. Similar gneisses are seen around the shores of Lake Mauve. In a large bay on the east side of this lake the gneiss shows several low undulations, with dips of five to fifteen degrees, and no limestone is visible. Trout lake is surrounded by hills of reddish-gray and hornblende gneiss, and below this the stream is navigable for about half a mile, whence a portage leads to the west shore of Maskinongé lake.

Trout lake

The strike of the gneiss on this lake is generally a few degrees east of north, and the dip changes from east to west several times, showing the presence of well-defined anticlinal folds. The portage from Trout lake reaches Maskinongé lake in a small bay near the south end. Here a small band of limestone occurs at the entrance of the bay, underlaid by grayish and rusty gneiss, which dips S. 70° E., $<50°$. This limestone extends south along the west shore of the lake and is separated from another band, seen on an island in the south-east corner of the lake, by a mass of hornblende rock which has the same strike. Dykes of pyroxene cut these and masses of white binary granite, or pegmatite, intersect the limestone.

Maskinongé river.

Descending the Maskinongé river grayish quartzose rusty gneiss appears at the elbow, a short distance below the foot of the lake, dipping E $<75°$ overlaid by limestone, to the east of which the gneiss again appears with a west dip $< 70°$, showing a synclinal in which the limestone occurs. Below this for about four miles to Cameron lake the rocks are gneiss, considerable distances along the stream, however, being drift-covered.

Cameron lake.

On Cameron lake, which is in the south-west part of the township of Clyde, a well-defined limestone band is seen at the south-west angle. The strike of this, as well as of the underlying gneiss, is N. 40° E., dip S. 50° E., $<75°$, on the north side of the bay at the outlet, but on the south side of the bay the dip is reversed to the north-

west $< 80°$. This limestone strikes directly along the south side of the lake, and can be traced north-east into another lake for several miles, when it disappears. To the south-west, its strike is along the course of the stream, but the area is drift covered.

Long and Kidney lakes.

To the south-east of Cameron lake a portage of half a mile reaches Long and Kidney lakes. The rocks in this direction are all reddish-gray gneisses, with bands of hornblende rock, and some of the bands are filled with small garnets. To the east of Kidney lake the country is very hilly and densely wooded, and evidently occupied by granitic and gneissic rocks.

Maskinongé lake.

Returning to Maskinongé lake, which has a length of about ten miles with a breadth of one mile to a mile and a half, the limestone appears in three parallel synclinals along the west shore, from the end of the portage mentioned to the north end of the lake. About the middle of the west shore an overturn in the strata is plainly seen, which makes the gneiss overlie the limestone for a short distance. These synclinals extend to the bay near the north-west angle, where the calcareous members apparently terminate. Ridges of intrusive white binary granite, weathering a grayish-white, occur in this area, as well as dykes of a coarse black hornblende diorite, which cut the limestone. The most northerly exposure of the limestone on this lake is on the north-west shore, between the large west bay and the north-west angle. It is underlaid by gneiss of the usual grayish type, but this band could not be traced inland, the rock in this direction being gray gneiss and quartzite. An attempt to burn lime was made at this place some years ago by a settler, but the rock used was a whitish quartzite instead of a limestone, and the attempt was, of necessity, a failure. Excellent limestone for burning, however, exists in the vicinity within a couple of miles of the Rouge and five miles from Labelle, so that lime could easily be obtained, instead of hauling from St. Jovite, nearly seventeen miles distant.

Lake east of Maskinongé lake.

Along the east side of Maskinongé lake a ridge of reddish gneiss and granite extends along its whole length and separates it from the waters of Muskrat lake (Lac des Frères) and several others which flow into the Lake of Three Mountains. A narrow band of limestone is seen about a fourth of a mile west of Lac des Frères on the portage; and a second band on the east side of the lake, occupying a synclinal and underlain by gray gneiss and quartzite. Crossing by a chain of lakes to Three Mountain lake, two other bands are recognized in synclinals, the anticlinal structure of the gneiss which separates them being quite clear. On Lac Brulé, to the west of Three Mountain

lake, hills of gneiss are seen on the north side which show a folded structure. No limestone appears on any of these lakes, but on Green lake, to the south-east of Three Mountain lake, a narrow band is seen, which may be the extension of one of those just noted.

Road from Montebello to Ponsonby.

In the townships of Amherst, Ponsonby and Suffolk, several new roads have been constructed by means of which sections across this part of the crystalline rocks have been made. One of the most recent of these extends northward from the village of Montebello, on the Ottawa, across the central portion of the seigneury of Petite Nation to the third range of Ponsonby, a distance of twenty-three miles, which will presently be described.

Crystalline rocks of Alfred township opposite Montebello.

Before giving the distribution of the limestone bands on the north of the river for this section, it may be well to point out the occurrence of the older rocks on the south side as seen at Alfred and Rockland. Of these the most important and instructive is that opposite Montebello where a beautiful display of gneiss, quartzite and limestone is presented, in a knoll near the ferry and to the south of the road about half a mile to the east. The rocks in the knoll have been smoothed by glacial action and disclose one of the finest examples of twisted structure to be found in the district. This has been photographed for the Geological Survey by Mr. H. N. Topley. The structure here is apparently an overturned anticlinal in the gneiss and the crumpled strata can be traced along the strike for nearly half a mile nearly east and west. The gneiss is flanked by well bedded quartzite which is in turn overlain to the east by the limestone with rusty gneiss inclusions. A similar quartzite is seen between the gneiss knoll and the river. The eastern extremity of the exposure is concealed by Potsdam sandstone and this also appears on the shore of the river a short distance west of the knoll. The development half a mile east of the ferry shows the usual series of grayish quartzose gneiss with a strike N. 50° E., dip. S. 40° E. 25°., < This is directly overlain by a band of whitish quartzite with the same dip and strike, and this in turn by limestone with rusty gneiss inclusions and thin bands, conformably with the other members of the section. The thickness of this band of quartzite is about 450 feet; that of the limestone could not be definitely ascertained owing to the covering of clay in this area; but the whole series including the gneiss presents all the aspects of a conformably sedimentary deposit. The lower red gneiss does not appear in this section.

Photographs.

Thickness of the quartzite.

Outcrops at Rockland.

A second small outcrop of the (Grenville series) on the south side of the Ottawa is at Rockland, near the mills of Mr. W. C.

CONTORTED GNEISS, NEAR FERRY LANDING, OPPOSITE MONTEBELLO, ALFRED TOWNSHIP, PRESCOTT CO., ONT.

Edwards, and represents the southward extension of the rocks seen at Rockland station on the Canadian Pacific railway on the north side of the river, where gneiss, quartzite and limestone are well exposed. At Rockland the exposure consists of a small mass of gneiss and limestone overlain directly by the Potsdam, the lowest beds of which are a very coarse conglomerate, succeeded by the sandstone of that formation, which forms a prominent escarpment directly to the south. This outcrop is too small to represent on our maps being mostly concealed by the Potsdam formation.

Pointe au Chêne.

Rensselaerite.

Limestone north of Pointe au Chêne.

Returning to the north side of the Ottawa, on the road west from Calumet, a small band of limestone associated with soapstone occurs about a mile east of Pointe au Chêne station. The exposure of steatitic mineral (rensselaerite) extends for nearly sixty yards and has been mined. It is associated with the ordinary gray gneiss. On the road north from Pointe au Chêne to Lake Commandant a well-defined band of limestone occurs which can be traced continuously for six miles and is probably continuous with slight breaks to the Rouge. It is also underlaid by grayish and rusty gneiss in which a synclinal structure is apparent. On the road from Avoca to Lake Commandant another band is seen with an exposed breadth of a fourth of a mile. This is on lots 2 and 3, ranges VI. and VII., of the Augmentation of Grenville. It can be traced for a short distance only to the south, but northward is probably continuous with the band which crosses the Rouge at the Bell chute, already noted.

Lake Commandant.

Kinongé (Salmon) river.

On Lake Commandant two bands are seen, one of which begins at the small bay near the south end of the lake and extends along the south-west shore to the north-east corner of the large island near the centre of the western end (Indian island). The other band follows the course of the south-west bay to the outlet of the Kinongé (Salmon) river. The two areas are separated by a ridge of reddish gneiss. They can also be traced on their strike at intervals to the northern extremity of the lake, where they also appear in two distinct but narrow bands, separated by a long point which divides the east bay from the main portion of the lake. The structure of both bands is synclinal and there are small irregular outcrops of a third band on the north-east shore of the lake. Here a prominent ridge of white-weathering quartzite occurs, but the greater part of the rock exposures around this lake are of grayish and reddish gneiss. The band from the south-west end of the lake has been traced at intervals along the course of the Kinongé river almost to its junction with the Ottawa. About one mile north-east of the lake several small outcrops

of limestone are seen on the Maskinongé river, indicating a broken band
Amherst. which extends for some distance along its course. It appears also near the Catholic church on range III. of Ponsonby, and may continue further north, since the valley of the river, up to Amherst corner, about five miles distant, is largely occupied by drift, and bounded on either side by high ridges of reddish gneiss. This valley of drift is in places nearly a mile wide. On the road from Amherst to Huckleberry chute on the Rouge, the only rocks seen were granitoid gneiss.

Ponsonby. Throughout the township of Ponsonby, with the exception of the outcrops just noted, calcareous beds appear to be absent. Great masses of reddish and reddish-gray gneiss are seen, for the most part well foliated, which extend into Suffolk, to the forks of the road at Ste.
Round lake. Emilie. On the road from this place into Addington gneissic rocks show at intervals; but at Round lake, which is in ranges I. and II., Addington, a narrow band of the limestone occurs on the road up the east side, and a band of the rusty gneiss is also seen at the extreme north end of the lake. The limestone is also exposed on a small point at the south end. Along the west side the hills of gneiss extend, and some of these are twisted in a wonderful manner.

Lac Vert to Lac des Sucreries. The road northward ends at this lake but a traverse across the northern part of the township was made from Lac Vert on the Nation, to Lac des Sucreries, in which several detached outcrops of the limestone were observed. It was found impossible, however, to connect these scattered outcrops with those further to the south as the surface was very rough and densely wooded. Synclinals were recognized in the gneiss at several points and it was observed that in most cases the limestones occupied these, while the different areas of the calcareous rocks were separated by anticlinals in the gneiss.

Ponsonby to Hartwell. Continuing westward, the road from Ponsonby crosses the township of Suffolk, by way of Ste. Emilie and Namur, and thence extends on to Hartwell, at which point roads diverge northward to Lac Simon and thence past the chain of lakes along the Nation river to Lake Nominingue, already mentioned, and southward to the villages of St. André Avelin and Papineauville, on the Ottawa river. Roads also extend westward from Hartwell into Ripon and north-westerly into Lathbury, where the settlements in this direction end. In the western part of the seigneury of La Petite Nation, roads are numerous and settlements are prosperous, owing apparently to the greater prevalence of the cal-
Road north of Montebello. careous formation. On the new road north of Montebello into Ponsonby several outcrops of limestone are seen which are evidently the northward prolongation of those which occur along the road north

CONTORTED LIMESTONE, WITH INCLUSIONS OF RUSTY GNEISS, SHORE OF OTTAWA RIVER, PAPINEAUVILLE, OTTAWA CO., QUE.

from Papineauville to St. André Avelin. These bands have been traced to the north-east for some miles and are bounded on both sides by grayish and rusty gneiss. The greater part of this area along the road to Ponsonby is however occupied by the underlying reddish and reddish-gray gneiss.

Papineauville

At Papineauville the limestone is well displayed on the shore of the Ottawa as well as along the railway near the station and on the road through the village. It is here much broken up by masses of white binary granite and the limestone along the shore is twisted in a very complicated series of folds, the included bands of rusty gneiss being well represented. This locality has also been photographed by Mr. H. N. Topley for the Geological Survey. The western edge of this limestone is seen near the corner of the road turning off to St. André Avelin, and it closely follows this road northward for several miles. Three miles north of the village, on a road east to the Montebello road a second calcareous band is noted, separated from that just described by an anticlinal in reddish and gray gneiss. Both these bands continue in a north-easterly course to the big bend in the Nation river at the place called the Portage. Their crumpled synclinal character is well seen at a number of points.

St. André Avelin.

The strike of the Papineauville bands, would, if continuous, carry them into Ponsonby, and on the road north of the Nation river and east of St. André Avelin three bands appear, separated by ridges of reddish and gray gneiss. Two of these terminate apparently a short distance north of the road from Montebello to Ponsonby, while the most westerly appears in a narrow band on that road several miles to the north, beyond which, however, it also soon dies out. These three bands should be, from the structure of the section, repetitions of the same, appearing in repeated synclinals. On the Little Rouge, a branch of the Nation from the north, a small band is seen which cannot be connected with any of those to the north or south, and which has a breadth of only a few feet. It is however on the strike of the Round Lake band in Addington but it is impossible to connect these in the fourteen miles which separate them.

Eozoon Côte St. Pierre.

About the village of St. André Avelin and for two miles west, as well as along the road thence south towards the mouth of the Nation river, outcrops of the limestone are frequent. In the village the strike is north-and-south, dip W. $<45°$ associated with gray and rusty gneiss. North of the village towards Hartwell the road passes over nearly level country for several miles, and at Côte St. Pierre about four miles from the village, several large masses of greenstone and granite are

seen which cut the limestone, and an Eozoon structure is found at the junction of the two series. Occasional masses of red granite-gneiss rise from the generally level plain, but just what area is occupied by the limestone in this drift portion is hard to say. Along the road from St. André Avelin to North Nation Mills outcrops of both limestone and gneiss are frequent and the structure is well seen. The gray and rusty gneiss is well exposed and the presence of three anticlinals in the separating areas of the reddish gneiss is recognized, the limestone and gray gneiss occupying the synclinals. From the forks of the road near the crossing of the Nation river, which is about three miles north of the station of North Nation Mills, a road extends east to the Papineauville road, but on this the rocks are all reddish and reddish-gray gneiss with the exception of a small band of limestone about midway. Several anticlines are seen along this road, as also on a road parallel to this along the south side of the river. North of North Nation Mills station the surface for some distance is covered with sand and clay terraces.

St. André to North Nation Mills.

North Nation Mills to Thurso.

Between this place and the Blanche river, which enters the Ottawa near the village of Thurso, large areas are also drift-covered. Several well-defined bands of limestone occur along the roads which traverse the area between these streams in the eastern part of the township of Lochaber and the Gore adjacent. Some of these are apparently on the line of strike of the bands recognized to the north of St. André and they are also seen in the northern part of the seigneury of La Petite Nation. The two western bands which are seen near Thurso village, can be traced on their strike, north-easterly into the adjacent township of Ripon, and thence into Hartwell, where several important bands are seen on the shores of Big lake or Lac Simon.

Lac Simon.

On the several roads traversed in this area, the strike of the rocks is not far from N. 20° to 40° E., varying occasionally through the action of intrusive masses, while the opposing dips at a number of points indicate the presence of the usual anticlinal structure. On the east shore of Lac Simon, where a continuous series of exposures of gneiss and limestone is seen for several miles, a series of anticlinals is visible in which the resulting synclinals in the limestone are beautifully seen. The limestone and associated gray gneiss are penetrated by masses of grayish binary granite or pegmatite, the composition of which is principally quartz and white felspar.

Limestone quarry.

On the large island in this lake and also on several of the smaller ones off the west shore, outcrops of limestone are well exposed, and near the west shore, for half a mile above the bridge at the Narrows. A quarry has here been opened for lime burning

in a mass of white crystalline rock well suited for that purpose. The study of the rocks around this lake is very interesting, the well stratified character of the several members being well displayed.

The country between the Rouge and Nation rivers north of the township of Suffolk and Ponsonby, is practically unoccupied by settlers. The only information obtainable, therefore, is from the several chains of lakes which abound in the area and along the connecting streams. From a careful examination of all the places that are thus accessible it is evident that the calcareous members of the system are much less extensively developed in this direction. This would tend to confirm the view expressed for the Rouge district, that the limestones and associate gray gneiss were a more recent development in the basin-shaped depression of the Ottawa.

Country north of lac Simon.

North from Lac Simon, which has a length of not far from nine miles from north to south, with a maximum breadth of two and a half, and occupies the northern portion of the township of Hartwell, the Nation consists of two branches. On the east branch are Little and Big Whitefish, au Sable, Vert and Cache lakes ; on the west branch are Long, Crooked, Zigzag, and des Iles lakes, while Big Bay lake, Lac des Sucreries, and several others are on the tributaries of this branch. The country around these lakes is generally rough and in places elevations from 400 to 600 feet above the lake levels are found, the rocks being for the most part a reddish foliated granite gneiss. Along the shores of these lakes small outcrops of limestones are occasionally seen which, however, are not traceable to any considerable distance on the line of their strike, while from the generally folded character of the rocks it would be extremely difficult to connect the exposures seen at the various points into a continuous extension of any one band, although they may and possibly do, represent the same band, reappearing from place to place through the agency of folds which are everywhere apparent.

Folded structure.

It has been usual to describe the structure of the crystalline rocks, north of the Ottawa, as having a general easterly dip. This view cannot now be maintained, since the examination of the entire area between the Rouge and Black rivers, shows a regular succession of folds, with well defined anticlinal and synclinal structure. The enormous thickness assigned to the gneiss of this area, in the report of H. G. Vennor,* is therefore misleading, since it was based on the assumption that these rocks over a long distance maintained a regular easterly dip.

*Report of Progress Geol. Surv., Can., 1876-77, pp. 299-300.

Big Whitefish lake, Nation chain.

On the Big Whitefish lake (Nation river)—(for it may here be remarked that in this district there are a number of lakes known locally by this name),—as well as on Little Whitefish lake, the only rocks seen were reddish and gray gneiss. The general strike of these is north. In places the rock is hornblendic and black. Two anticlinals are seen in the rocks around the shores of these lakes, and a short distance west of the big bay on the west side of the former, a large dyke of coarse black dioritic rock cuts across the gneiss. In places this has the aspect of a brecciated rock with angular pieces of black hornblende rock disseminated. The dyke extends for nearly half a mile, and is flanked on the north-west by black hornblende and gray gneiss, which continues up to the head of the lake.

Lake Doré.

A chain of smaller lakes extends for several miles north-and-south, following the strike of the rocks. This chain lies to the east of Little Whitefish lake, and to the north-east of Lac Simon, and from a mile to a mile and a half distant from the former. Through the centre of the chain, on several islands in Lake Doré, a narrow band of the limestone is seen underlain by rusty quartzose rock, which has a strike nearly north-and-south.

Green lake.

From the north end of Big Whitefish lake a portage along Green creek leads to Green lake, about one mile and a half distant. On this route three small lakes are crossed, on the second of which limestone occurs at the south-west angle, with rusty gneiss, dipping to the south-east, while on the small creek connecting this with the third lake, similar limestones are exposed, dipping nearly west $< 50°$. Thence to Green lake the rock is the underlying gneiss. At the entrance to this lake the dip is again reversed to S. 55° E. $< 15°$. The limestone in its lower portion holds the usual inclusions of twisted, rusty gneiss, so common in the Grenville series.

On the west shore of Green lake the limestone occurs in three well-defined bands separated by anticlinals in the quartzose dark-gray gneiss. The strike of the rocks varies from N.E. to N., the angle of the dip either way being from 20° to 50°. On the south end and east side of the lake two other synclinals were observed, with limestone separated in the same way by beds of gneiss. These limestone and gneiss bands could not be traced very far in either direction, owing to the nature of the country, but similar bands appear further north on a small chain of lakes lying to the east of Lac au Sable, and it is possible that the outcrops noted on the west side of Long Point lake in Minerve township, already described in the Rouge system, may repre-

sent their northward extension, as the strike of the several bands would carry them in this direction.

Lac des Sucreries.

By means of a chain of small lakes to the east of Green lake, we reach Lac des Sucreries, on which the section can be extended nearly to Cameron lake on the Maskinongé river. On one small lake midway, a small band of limestone was seen underlain by black and gray gneiss, in the vicinity of which was a large dyke of black or dark-gray diorite. On the several portages the rock, where exposed, was the usual black, reddish and gray gneiss. On the north side of Lac des Sucreries, quartzose gneiss underlies bands of black or very dark-gray siliceous limestone, the latter in bands from six to eight feet thick; the dip on the west side of the exposure being to the east at an angle of 40°, but on the eastern margin, this is reversed to S.E. $<30°$, where the rock becomes grayer in colour. The underlying rock here is a red orthoclase foliated gneiss. Going eastward the dip of the gneiss soon changes to E. $<20°$, beyond which, to the eastern end of the lake, the shores are drift-covered. Similar dark-coloured limestones are seen in two small islands near the centre of the lake on the northern side, and here the rocks are cut by dykes of hornblende and pyroxene.

Bands of crystalline limestone also appear on the south shore of this lake about midway, associated with the usual rusty quartzose gneiss. The nearest calcareous rocks to the south are the outcrops noted on Round lake in Addington, while to the north the nearest are those seen on the west shore of Maskinongé lake, in the township of Labelle.

East branch of the Nation river.

Ascending the east branch of the Nation, a portage leads to Lac au Sable. The shores are mostly occupied by gneiss of the usual varieties, but on the east side, north of the point near the mouth of a small creek which discharges the waters of a small chain of lakes from the east, dark-gray siliceous limestones occur along with black hornblendic gneiss. West of the inlet or Narrows, at the north end of the lake, limestone also occurs, associated with grayish quartzose gneiss, dip W. $<60°$. The upper end of Lac au Sable is in the western part of the township of Minerve. At the north-east angle of the lake low-lying ledges of limestone dip S. 70° W. $<35°$. But few ledges show along the shores of this lake, and where seen, with the above exception, are of grayish limestone, with rusty and black gneiss, the general strike being from N. to N. 10° W.

Lac au Sable

The stream entering the head of Lac au Sable is for the most part sluggish to Lac Croche, where it takes its rise. Several small lake-

expansions occur, but ledges are few, and such as are seen, with one exception, consist of gray or dark hornblende gneiss. On the second lake-expansion below Lac Croche, a small band of white crystalline limestone is associated with hornblende gneiss, but the outcrop is very limited.

Lac Croche. Around Lac Croche the only rocks seen are gneisses, red, grayish and quartzose. The strike is generally north and the dip is east $<40°$ to 80°.

Lac des Iles. From this lake a portage of about a mile in length, leads westward to Lac des Iles, which is at the head of the east fork of the west branch of the Nation. A small band of the limestone is seen on an island near the north-east corner of this lake, overlying fine-grained quartzose gneiss. The strike at this place is N. 25° W., the dip is west. An anticlinal in the dark-gray hornblende and garnetiferous gneiss is seen a short distance west of this outcrop. On the west side of the lake, half a mile below its northern end, is a deep bay in which the rocks are mostly fine-grained and quartzose. A heavy dyke of gray binary granite cuts the gneiss at this place but no limestone was observed, though a synclinal occurs in the gneiss. The islands with which the lake is dotted, are with the exception noted, all composed of gneiss. In places this is rusty and quartzose, but certain bands are garnetiferous. The strike is generally N. to N. 10° W. In the lake to the south, between this and Zigzag lake, a small band of limestone appears on the east shore, underlain by rusty gneiss and quartzite, and a second band occurs towards the south end of the lake near the portage to Zigzag lake, which occupies a well-defined synclinal. The limestone here is very rusty and disintegrates readily, forming a coarse calcareous sand.

Zigzag lake. Around the shore of Zigzag lake the only rocks seen are grayish and dark hornblende gneiss, in places much twisted and crumpled, presumably from the presence of intrusive dykes; but at the outlet of the Crooked lake. lake, a short distance above Crooked lake a small band of limestone appears on the point. Similar calcareous rocks, in two bands, also show on the east shore of Crooked lake, south of the inlet of the Nation river, separated by well-defined anticlinals in grayish and rusty hornblende gneiss. The general strike of the rocks is north. Around the north shore of this lake, west of the inlet, several bands of the limestone occur in layers of four to five inches thick. The gneiss with which they are associated, is much disturbed and dykes of white binary granite, largely composed of felspar, are seen in the vicinity. The south shore of the lake shows occasional ledges of black, rusty and grayish gneiss.

Two branches of the west fork of the Nation are found in the vicinity of Crooked and Zigzag lakes. The most easterly discharges a lake several miles long containing numerous islands, and named Big Bay lake. It is situated on the western line of the township of Loranger, while on the westerly branch are lakes Sugar Bush, Long and several others, unnamed. On Big Bay lake, outcrops of limestone are seen both on the shores of the lake itself, and on several of the many islands near the centre and southern end. Several of these bands are coarse-grained, yellowish and dolomitic. They are associated with bands of black hornblende and quartzose gneiss, and dip uniformly to the north-west $< 45°$ to 50°, but show at several points evidence of great disturbance and overturning of the strata. The gneiss bands are frequently garnetiferous, and masses of intrusive white granite are common. On several of the islands in the northern part of the lake a distinct anticlinal structure is seen in the gneiss; and occasionally the rocks are thrown into a series of crumplings and folds in which overturn dips are clearly visible. The east side of this lake is generally low, but ledges of grayish gneiss are seen at intervals, as also along the shores of a deep bay which extends to the eastward. Hills of reddish and gray orthoclase gneiss rise around the lake. From the south-west angle a series of portages and small lakes leads across to Long lake, the intervening rocks, where exposed, being all gneiss. Long lake is about five miles in length from north to south. The shores show numerous ledges of reddish-gray foliated gneiss, often coarse; but near the outlet at the southern end, leading to Sugar Bush lake a small band of yellowish dolomitic limestone appears, containing lumps of dark gneiss and pebbles of quartzite. A synclinal occurs at this place, the underlying rocks being rusty and hornblende gneiss.

Big Bay lake.

Long lake.

On Sugar Bush lake, which is reached by the creek from Long lake, the rocks are mostly gneiss. Indications of limestone are present in the rusty bands on the east shore, but no well-defined ledges are visible, except at the south end where the portage leads across to Crooked lake. On the north shore a heavy dyke of black rock (diorite) is exposed, which holds pieces of slaty-looking gray gneiss in the mass of the rock. The west shore of the lake shows occasional ledges of reddish quartzose gneiss and the usual folded aspect is seen at several points. At the south end the limestone is underlain by white quartzite. The general strike of the rocks on this lake is N. to N. 10° E. On the portage to Crooked lake, half a mile distant, the only rocks seen are red and gray gneiss. No limestone shows in this direction, but on the east side of Crooked lake two well defined areas are exposed along with the characteristic rusty gneiss.

Sugar Bush lake.

Lower Long lake.

Going south to the Lower Long lake on the Nation river, much drift is found along the connecting creek, but, in the northern narrow prolongation of the lake, the calcareous bands are infolded with the gneiss in such a manner as to clearly indicate an overturn of the strata. A well-defined anticlinal is seen on the west shore of the lake a short distance to the south of this place with a corresponding synclinal still further to the south, in which is a second band of limestone. Lower Long lake is about eight miles long from north to south. A considerable portion of the west shore is low and sandy, with occasional outcrops of the gneiss. At the point on the west side of the narrows at the south end, ledges of serpentinous and tremolitic limestone appear much twisted and broken up, owing doubtless to the intrusion of dykes in the vicinity. From this point a depression extends southward to the north-west angle of Lac Simon and occasional outcrops of limestone lead to the inference that the limestone outcrops seen at the upper end of that lake near Edward's dépôt, are continuous with those on Long lake.

Folded character of rocks.

On the east shore of Long lake limestone appears in three bands, so removed from each other, and separated by areas of reddish gneiss, as to make them three distinct bands or repetitions of the same by folding. The dips of the underlying gneiss would indicate the latter structure, although the strata are in places in a nearly horizontal attitude. Reverse dips are, however, readily seen in the underlying rocks, showing a folded structure at several points.

Extent of limestone bands.

In all this area between the Rouge and the Nation, though limestone bands are frequent, the endeavour to trace any of them to any distance continuously, was found to be impossible except in the area, near the Ottawa. In some cases this has been done for several miles where depressions would indicate that these have been caused by the decay of the softer calcareous rocks; but, under the most favourable conditions, little reliance could be placed on the finding of areas, separated by tracts of unbroken forest, and apparently upon the same strike in their presumed place on parallel lines of section. Even on the lake shore so many gaps occur in the rock outcrops, owing to sand deposits, that continuous sections can rarely be obtained; while in other places, through the presence of intrusive masses of granite and diorite, or the agency of faults, the continuity of strata over any considerable area is rarely found. From the frequently recurring changes of dip in the gneissic and calcareous strata, however, it is plainly seen that the entire series of rocks in this area is thrown into a number of recurring folds and that the successive bands of gneiss and limestone are repeated, sometimes at very frequent intervals.

NATION AND LIÈVRE RIVERS.

A great portion of the country between the Nation and the Lièvre rivers is much more inaccessible than that just described. Roads are confined almost entirely to the townships near the Ottawa, very rarely extending north more than twenty miles from that river, while it is not so readily accessible by canoes. The route traversed extended from near the centre of the west shore of Long lake by a portage of three miles along the south side of Simon creek in which distance two small bands of limestone were crossed about midway on the trail, and thence by following a small chain of lakes with several portages to Lac des Ours (Bear lake), which was reached at its southern angle. With the exception of the bands noted on the first portage no limestones were seen on this route. Around the shores of Bear lake the prevailing rock-masses were hornblendic reddish and gray gneisses. Large dykes and masses of white binary granite (pegmatite) show at intervals, more especially along the south-east portion of the lake. The general strike of the foliated gneiss is N. to N. 15° E. and the dip changes from east to west, several anticlinal folds being easily recognized.

Character of country.

Bear lake.

From Bear lake to the Lièvre river a canoe-route exists, either by descending Bear creek to its junction with the Lièvre river, in the southern part of the township of Wells, or by making a portage of a mile and a half near the intersection of the stream with the eastern line of the township into a chain of lakes, in which are included lakes Brochet, L'Aigle, Serpent, Corbeau, St. Germain and du Cerf (Stag lake), from the latter of which Stag creek reaches the Lièvre in the township of Dudley, about ten miles south of the Kiamika river, an important tributary from the east.

Along the course of Bear creek no ledges other than gneiss were seen with the exception of certain intrusive masses of whitish binary granite. At several points loose pieces of limestone were noticed and ledges of the same may exist, which are concealed along the stream by drift-sand and gravel. Shortly before reaching the township of Wells great ledges of gneiss cross the stream producing rapids and falls, the rock being almost as well bedded as the ordinary Potsdam sandstone, and these have the aspect of an altered quartzose sandstone, rather than of a quartzite, though a gneissic structure is apparent. Near the beginning of the portage to Brochet lake greenish pyroxenic rocks cross the stream. The general strike of the gneiss and quartzose rocks is N. 10° E. to N. In this part of the stream three well-defined anticlinals are seen.

Bear creek.

Brochet lake. On the portage to Brochet lake the surface is sandy and flat, only one outcrop of gneiss being observed near the crossing of the North branch. At the north end of the lake, near the outlet, grayish hornblende gneiss occurs with a band of limestone, the strike being north and the dip west. The shores of this lake are generally low and sandy.

Lac à l'Aigle. A portage of a third of a mile leads to Lac à L'Aigle on the east shore of which no ledges are seen, but on the west side reddish-gray and black gneiss comes to the shore with blocks of limestone on the beach, so that it is probable the band noted on Brochet lake continues northward under the water. Along either side, ranges of low gneissic hills rise to a height of 100 to 150 feet and extend in a north-easterly direction. A creek flows from this to Serpent lake, through generally low land, showing no ledges, but from scattered blocks of the limestone it is probable that this band continues along its course. The waters of Serpent lake are discharged into the Lièvre by Serpent creek. This stream was traversed by Mr. L. R. Ord, in 1877. It leaves the lake about midway on the west side, is about ten miles long and very crooked. The valley through which it flows is densely wooded and rock exposures are few. Mr. Ord in his notes says of it 'for the first three miles from the lake the rock consists of small exposures and fragments of limestone and dark-weathering gneiss, strike N. 35° E. and dip N. 55° W. $<40°$. Then the creek runs west of south for a mile and a half on the strike of dark gneiss, to a marshy lake; thence it curves north-west and for a mile crosses gneiss, when it again turns to the south of west and as far as McCabe's mill on the town line of McGill, a distance of about two miles, the rock is limestone with a north-west dip. For sixty chains below the mill the limestone appears at intervals and from this to its junction with the Lièvre the country is flat and sandy.'

Serpent lake and creek.

Notes by L. R. Ord.

Serpent lake. Returning to Serpent lake, the west shore from the southern end to the outlet, shows occasional ledges of reddish and gray gneiss with interstratified bands of quartzite, the strike of which is nearly north and south. These form low hills; but on the east side of the lake great hills of the red gneiss appear, and similar high hills rise to the west about one mile inland. A small band of limestone shows near the north end of the lake which is underlain by the usual gray and dark gneiss.

Lake Corbeau. A creek, half a mile long, leads thence into Lake Corbeau to the north. Here ledges of hornblende gneiss and limestone are seen in the small bay near the south-east end, dipping east at a low angle. Fifty yards further north red gneiss appears, underlying the limestone

dipping W. < 20°. Limestone also shows at the north end of the lake with the same dip and strike, and half a mile further north another exposure shows a dip to the east, <78°. This is underlain by the usual rusty gray gneiss.

The west side of the lake shows the presence of limestone associated with the gray gneiss the strike being N. 10° E. < 50° to 80°. On a small lake to the north-west of this, on the route to Stag lake, several small outcrops of limestone appear which may represent the extension of the bands seen on the west side of Lac Corbeau. Thence to Stag lake, crossing lake St. Germain, on which ledges of white granite cutting the red gneiss occur, the country in the immediate vicinity is low.

Stag lake (lac du Cerf) is about four miles in length from north to south, with a breadth of a mile to a mile and a half. Near the centre a small group of islands, not shown on the map occurs. Two long bays extend from the upper end of the lake to the north-east and north-west, and ranges of high hills of gneiss and granite rise both to the east and west. Stag lake.

The rocks on the south-east part of this lake are reddish and quartzose gneiss. These are cut by large masses of grayish granite. The red rocks extend along the east shore in a series of folds, the strike in this area being nearly east and west with dips to the north and south. About half a mile from the south east angle of the lake these are overlain by white crystalline limestone, containing scales of mica, and underlain by the usual rusty gneiss and quartzite. Thence rusty gneiss with a band of limestone extends eastward into a bay, the shores of which are composed of sand, often calcareous. On the islands near the centre of the lake the rocks are a mixture of garnetiferous gneiss, limestone and white granite, and similar rocks occupy the western shore of the lake as well. Rusty gneiss generally accompanies the limestone, and garnetiferous bands are common. Along the east shore similar rocks are seen, the strike changing to north, but the beds are often minutely crumpled as in those at Papineauville on the Ottawa, showing the disturbing action of the white granite, the series at the two places being identical. On the north side of the north-east arm, which is apparently underlain by the limestone, an anticlinal is seen in the rusty gneiss; and between this and the outlet, which is on the north-west arm, the anticlinal structure is repeated and another band of limestone appears.

At the eastern entrance to this last bay, calcareous bands with quartzite strike north and dip east <70°. A small dyke of pyroxene is seen

Stag lake to the Lièvre river.

along with the granite, and bunches of limestone occur in the latter as if caught in the intrusive mass. From Stag lake a passage of 250 yards connects with Little Stag lake, the shores of the latter being almost entirely of limestone. An island towards the middle of the lake in the direction of the outlet is also formed of limestone. Gneiss however comes in at the south-west angle. The shores are generally low, and undulations in the gneiss and limestone are visible at several points. The country to the north and west becomes much less hilly indicating presumably the presence of much more extended areas of the calcareous rocks in this direction, though a somewhat extensive covering of sand and clay conceals the outcrops except at scattered intervals. This predominance of the limestone probably marks the eastern limit of the Lièvre basin, which has a breadth to the west of some miles and will be presently described. From Little Stag lake a stream empties into the Lièvre opposite a long island in the township of Dudley, and just below the junction with the Lièvre, ledges of yellowish dolomitic limestone are seen holding scales of graphite with bands of rusty gneiss which dip W. $<75°$. Near the lower end of this island garnetiferous gneiss dips E. $<80°$. A considerable ridge extends along the west bank of the river about 250 yards distant, but the immediate vicinity of the stream is low and occupied with drift-sand.

Little Stag lake.

The Lièvre river.

Before describing the distribution of the rocks along the course of the Lièvre, near the lower part of which some of the most important mineral deposits in the province of Quebec are situated, including apatite, mica and graphite, we may consider the structure as seen between the Nation and the Lièvre near the Ottawa.

Area between Nation and Lièvre rivers.

The district between the Nation and the Lièvre, near the Ottawa, embraces the townships of Buckingham, in part, Lochaber, Derry, near the Ottawa, Mulgrave and Lathberry, Ripon and Hartwell, and a portion of the seigneury of La Petite Nation and the Gore of Lochaber. The principal stream traversing the district is the Blanche, which enters the Ottawa about half a mile west of the village of Thurso. The three branches of this stream in the townships of Villeneuve, Lathbury and Mulgrave have chains of lakes, none of which are of large size, but by means of which the area in question can be readily traversed by canoes, while the portion near the Ottawa is intersected by numerous roads, so that the geological features can be readily ascertained.

Blanche river.

Roads north of Thurso.

Roads from Buckingham village and Thurso meet at St. Malachi and continue north to Blanche lake, a short distance north of the outlet of which it forks, the eastern route continuing across Mulgrave into

Ripon, where it joins the road from North Nation Mills to St. André Avelin, and thus affords a good section across the strike of the gneiss and limestone. The left-hand road continues north to Long lake, in the north-west part of Mulgrave township. A road also extends north-east from Thurso village, crossing the Sinsic river, and thence into the north-east portion of Lochaber. Thence dividing, the west fork reaches Heart lake on the east branch of the Blanche, while the other continues on to the road leading to St. André Avelin. Along these roads and around the shores of some of the lakes, bands of limestone are seen, some of which can be traced for short distances only, while others are continuous for some miles.

Limestone bands.

Among the most important of these is probably that which is recognized in the eastern part of Lochaber, appearing first on ranges V. and VI. This band, with a north-east direction, crosses the Gore of Lochaber and the western part of La Petite Nation to the Nation river, west of St. André Avelin, beyond which it is largely concealed by drift, through which, however, an occasional outcrop appears, by which its extension into the township of Suffolk can be recognized. Several well defined anticlinals are seen in connection with this area.

Thurso to Hartwell.

A second and still more extensive band can be traced almost continuously from Thurso village, where its southern terminus is concealed by the drift of the Ottawa valley, through the eastern part of Lochaber and Ripon, till it reaches the valley of the Nation river, to the south of Lac Simon, in Hartwell township ; thence its distribution northward has already been described. The entire length of this band from Thurso to its northern extremity in Long lake of the Nation chain is not far from forty miles.

Lochaber township.

The roads which intersect the township of Lochaber show numerous outcrops of limestone. A somewhat extensive band appears near the Ottawa river at Rockland station, on the Canadian Pacific railway, interstratified with gray gneiss. This band on the road north of the station has a breadth of nearly a mile, its eastern margin being concealed by a mantle of clay. While continuous to the north the calcareous portion gradually decreases, and the underlying gray gneiss appears. Generally, however, the bands of limestone in Lochaber are of no great breadth but are repeated at frequent intervals in a series of folds, with many changes of dip, and anticlinals in the rusty and gray gneiss are seen. A somewhat important band emerges from beneath the clay covering near the line between Buckingham and Lochaber on range IV., and can be traced northeasterly to the village of St. Malachi, where, east of the post office, it has a breadth of nearly half a mile,

beyond which, to the north, it is probably continuous to Green lake on the east branch of the Blanche. Thence it passes to Heart lake and up the valley of the Sinsic brook, the course gradually changing more northerly, till it passes into the eastern part of the township of Lathbury. This band is well defined and has a breadth in eastern Mulgrave of nearly a mile.

Mulgrave band.

Branches of Blanche river.

Another important area is continuous from Buckingham village, where it is well exposed at the falls below the mills, with slight interruptions north-east, past St. Malachi, to the shores of Blanche lake. Here it divides, one arm crossing by the eastern shore of the lake where it becomes serpentinous and is associated with dykes of pyroxene and from this point extends up the middle branch; the other continues up the west branch through Gull, Hawk and Lady lakes, beyond which it has not been traced. This band is also associated with serpentine on Gull and Hawk lakes and attempts have been made to mine the small strings of asbestus (chrysotile) which occur in the serpentine both here and on Blanche lake. The quantity of the mineral is however too small to be of much economic importance. West of the bands just described, others occur to the north of Buckingham village, but these have not been traced to any considerable distance, owing to the difficulty of traversing the rough and comparatively unsettled township of Derry. A small band was also noted at the outlet of the chain of lakes from Echo Beach lake on the western branch of the Blanche, which also could not be traced owing to the drift.

Portland east.

Furthur west in the township of Portland East, a band of limestone is visible between Lake Tamo and Clay creek, which is exposed for a couple of miles. It extends north and south in the direction of the lake valley and may pass beneath its waters. The shores of Lake Tamo however are frequently sandy and rock exposures are few. The band continues northward into Clay lake.

The intermediate areas separating these calcareous bands, are for the most part occupied by grayish gneiss which, near the limestone, assumes the usual rusty character and becomes interstratified in thin bands. This gray gneiss, which is also quartzose, is associated in its lower part with dark hornblendic layers and these pass downward or rest upon the reddish members of the system. Intrusive masses of the white granite are frequent and among other places can be well seen on the road east of St. Malachi. Dykes of pyroxene rock are also more numerous than in the areas to the east, and mines of apatite and graphite have been opened at a number of places. On the whole

Pyroxene and apatite.

however it may be said, that the conditions favourable to the occurrence of apatite and mica over the greater part of the area just described are not so favorable as in that more closely bordering on the Lièvre where important mines of apatite are situated.

The gray and black gneiss of this area has a well marked stratified aspect, and there is apparently a regular passage upward into the calcareous portion. Other parts of the gneiss, notably the reddish members, are generally foliated only; but sometimes this is absent and the rock is a massive granite. Several dykes of a blackish green, generally fine-grained diabase rock traverse both the gneiss and the limestone in a generally east-and-west direction. These dykes are mostly narrow, often only a few inches in thickness while in places they have a breadth of several feet. They do not appear to be connected with any special mineral development where they cut the ordinary gneiss, but sometimes when found with the phosphate-bearing pyroxene, they are associated with developments of apatite. Diabase dykes.

THE LIÈVRE RIVER.

The Lièvre is a much larger and more important stream than those already described to the east. It has a length of not far from 250 miles from the chain of lakes at its source to its junction with the Ottawa river near Buckingham station on the Canadian Pacific railway, about twenty miles east of Ottawa city. It has been carefully examined for over one hundred miles north from its mouth or to the junction of the Tapanee, a branch from the west, from the head of which a portage connects with the Piscatosin lakes and river on the Gatineau waters. The upper part of the stream from Stag creek was examined by Mr. Ord in 1877. The lower portion of the river, in the townships of Buckingham and Portland, is especially well known since it traverses the great apatite-bearing district north of the Ottawa; and on its banks, or in close proximity, are situated the most productive mines of this mineral in the province. The Lièvre river.

The stream is generally easy to traverse, the current for long stretches being slow. Heavy rapids occur at intervals, but the principal descent in the stream is at the High falls, twenty-five miles from the mouth. This fall has a descent of about 130 feet. High falls.

In the lower part of the river, between the railway and Buckingham village, falls and rapids occur, the descent in the three miles being not far from 250 feet. The surface along this area is largely covered with Buckingham to High falls.

sand, the underlying rocks being mostly gneiss, with which, however, are associated small bands of limestone. Limestone also appears along the road down the west side of the river, about one mile below the bridge at the village, but owing to the covering of sand, its relations can not be readily seen. From the landing at the village the current is sluggish, and steamboats ascend to near the foot of the High falls, just above the northern line of the township of Portland. The Little rapid, which formerly interfered with the navigation of this part of the stream, is now overcome by a dam and lock. By the former the stretch of broken water about three miles below the Falls, known as the Long rapid, has also been obliterated.

Mining district east of the lower Lièvre river.

The country east of this portion of the Lièvre is very hilly and broken. About eight miles above the landing at the village of Buckingham, the celebrated mines known as the Emerald, the Squaw Hill and the Ætna are situated, while in the immediate vicinity of the Little rapids, are the London and the Little Rapids mines. About seven miles further up the river, the wharfs of the North Star mines are placed. The mines themselves are situated on lot 18, range VII., Portland east, on the summit of a high ridge, overlooking Lake Tamo, about three and a half miles east of the river. In this direction also are the Philadelphia Company's mines on lot 26, range VIII., the Chapleau mine, on lot 7, range VI., with several others of less importance, judging from the amount of development work performed. Near the landing of the North Star, in a bluff overlooking the village of Notre-Dame de la Salette, are the Salette mines, while two miles, further north is the landing from the Villeneuve mica mine. This mine is on lot 31, range I., Villeneuve, the distance by road from the landing being nearly five miles.

Mining areas west of the Lièvre.

On the west side the surface is much less rugged as far as Chalifoux's landing, opposite the wharfs of the North Star mine. At this place the succession of hills, on which are situated the Ross Mountain, High Rock, Crown Hill, Star Hill and Central Lake mines, and further north, the High Falls mine, come to the river. The distance of these from the river is from half a mile to a mile and a half. These hills rise from the stream to elevations of 500 to 700 feet, and in this range of hills are included the most productive apatite mines of the district.

The country-rock throughout this area is mostly a gray gneiss, the limestone rarely appearing. Along the river small outcrops mixed with rusty gray gneiss, show at the Narrows, about five miles north of the village of Buckingham. Limestone also occurs with the rusty gneiss in the village itself, and a band extends thence north-east,

which has already been referred to. Much of the river course in this part lies between clay banks, and rock exposures are few. North of the Little Rapids a small outcrop is seen on the bank near Salette village, the extension of which cannot be traced owing to the deposits of clay.

Pyroxenes and intrusive rocks.

In addition to the gneiss which is so largely developed throughout this area, great masses of pyroxene appear in the vicinity of all the mines. These, with binary granite (pegmatite) and diorite, form a great part of the hill on which the Emerald and Ætna mines are located, the gneiss in contact being generally rusty and having a shattered aspect as if from the action of intrusive masses.

The same may be said of the hill ranges at the other mines, the intricate admixture of the granite, pyroxene and gray gneiss being everywhere apparent throughout the entire mining area.

Rocks about High falls.

The gneiss at the head of the High falls strikes N. 15° E., but at the great bend above the falls this changes to N. 10° W. the dip being E. $<70°$. Intrusions of pyroxene and white granite are seen in the vicinity and on the hills to the south-west, and small deposits of mica and apatite occur. At the brook flowing from Bowman lake a fourth of a mile above the fall, a considerable band of limestone is seen with a breadth across the strike of nearly half a mile, or to near the shore of the lake, where it is underlain by gray and rusty gneiss. A little further west, on the west side of Bowman lake, the High Falls mine is situated on the east side of a ridge of gneiss and pyroxene.

The Lièvre above High falls.

The band of limestone just mentioned probably extends southward along a depression to Central lake about one mile distant, where it shows in a narrow outcrop. But northward it appears along the river on both sides and is much mixed with the gneiss especially in the lower part of the band. At the mouth of the stream from Scalier lake two miles further north, a similar band appears, but the strike is here nearly east-and-west and just at the mouth of the stream the usual rusty gneiss shows in underlying ledges on the south side of the river. The deflection in the strike at this place is doubtless due to the intrusions of granite in the vicinity, since similar variations are seen in connection with the rocks at all the mines in the pyroxene belt.

Steamboat route.

From the mouth of Scalier creek to Bear creek in the township of Wells, the banks are often of clay and sand; the current is sluggish and a steamboat traverses the river to the foot of Pine rapid, nearly fifteen miles from the High falls. Hills of grayish and reddish gneiss rise on either side. Several thin bands of limestone are seen in this

distance, associated with rusty gneiss the thickness of the calcareous members ranging from eight to twelve feet where exposed. About two miles below the Ox Bow, which is near the north line of Villeneuve township, a twelve foot band of the limestone in gray gneiss is twisted and overturned in a wonderful manner, showing well the enormous disturbance to which these rocks have been subjected, but no calcareous areas of any considerable extent are seen along this portion of the river.

Terraces.

Between Bear creek and Pine rapid, limestone outcrops are seen at two points, the most conspicuous being about one mile below the latter place, where on the east bank of the stream nine bands, in thickness from five to ten feet, are separated by bands of grayish rusty gneiss, the gneiss being in about the same proportion. Beautiful examples of terraces in the sand and gravel are seen along this part of the river, as many as three being easily recognized.

Rapide des Pins.

The Rapide des Pins (Pine rapid) is near the center of the west boundary of Wells, and consists of a heavy rapid ending in a fall of eight to ten feet, over limestone interstratified with and underlaid by gray rusty gneiss. The dip at the lower end is N. 50° E. $<40°$. A short distance above this is the Rapide Croche, also over limestone in which are large inclusions of black gneiss, the strike being north and the dip east and west in a syncline. Between this and Lac des Sables two other rapids are passed, viz., the Cedars and the Iroquois. Calcareous strata are frequently associated with the usual gray gneiss which also underlies the limestone, and from the diverging dips shows an anticline in the lower beds. It is evident along this portion of the Lièvre that these calcareous bands are in part at least repeated by folding having a general strike of N. 10° W. to N. 10° E.

Lac des Sables.

About three-fourths of a mile below Lac des Sables a band of limestone thirty-five feet wide crosses the stream, dipping S. 10° E. 70°. Near the junction of the creek from Big Whitefish lake the calcareous strata are greatly crumpled and a large dyke of black hornblende diorite comes to the river from the south. This is in the south-west angle of the township of McGill. The limestone here has a breadth of several hundred yards and is probably the extension northward of a large area seen on the lake to the south. Furthur north similar limestones again come in, and are separated from the last by an anticline in the gneiss, and these extend in a series of outcrops to near the Iroquois rapid a fourth of a mile below the mouth of Serpent creek.

Just below the lake expansion in the northern part of Bigelow, micaceous limestone and rusty gneiss again appear, the latter forming an anticline with the limestone on either side.

Lac des Sables.

Lac des Sables is about three miles long from north to south and one to two miles wide. The eastern side is bounded a short distance back from the shore by high ridges of reddish gneiss. The shore shows one small exposure of impure limestone, the rocks being mostly hornblendic, quartzose and garnetiferous gneiss. The strike is N. W. the dip S. W. $<80°$. On the west-side there are two bays of which the most southerly as well as the point between the two, is composed of garnetiferous and dark gneiss with a strike N. 60° E. At the head of the south bay this is overlain by a band of limestone with an exposed thickness of fifty yards, and having a strike nearly at right angles to that on the east side of the lake. A lofty ridge of granite-gneiss extends along the south-west side of the lake, and no limestone appears in this direction.

The north shore of the lake is mostly sand, and from the extremity of the north-west bay a portage extends westward to Thirty-one Mile lake on the Gatineau waters, by way of Lac au Foin.

Graphite of Babiche rapid.

Above Lake des Sables the banks of the Lièvre show no ledges for several miles, but about three-fourths of a mile below Babiche rapid, which is half a mile north of the line between the townships of Wabassee and McGill, occasional ledges of black and gray gneiss appear, and at the rapids themselves bands of twisted gneiss and limestone occupy the bed of the stream. An opening has been made along the portage in grayish gneiss for graphite, scales of which are thickly disseminated through the rock. A dam has been built across the river at this place with the object of making the upper part of the river navigable for steamboats, but the force of the current has cut away the east bank so as to render the work at present useless. The strike of the rock at this place is north.

Babiche rapid to Long island.

From Babiche rapid to the foot of Long island or to the mouth of Stag creek where our section from the Nation reached this river, the rocks seen are mostly limestone. The strike is generally north-and-south but this is sometimes deflected by the presence of masses of granite. In the lake-expansion in the southern part of the township of Dudley, alternations of limestone and rusty gneiss occur along with masses of white granite, and at the foot of Long island a ridge of garnetiferous gneiss, with rusty and quartzose bands, rises on the east bank and has a dip of S. 80° E. $<80°$.

Mr. L. R. Ord on the upper Lièvre.

The upper part of the Lièvre was traversed in 1877 by Mr. L. R. Ord, and from his notes it would appear that along the upper portion of this section the same alternations of gneiss and limestone extend for many miles. Mr. Ord says: 'the main channel is on the west side of Long island which is flat and sandy. From one mile above the foot to the head of the west channel, a band of limestone runs along the shore and on the east shore a band of dark-weathering gneiss dips south-east. From the head of Long island to the Wabassee farm about three and a half miles, all the visible exposures are small bands of limestone on the west bank which appear to strike with the river course, and a band of white-weathering gneiss leaves the river at the head of the island and keeps off to the east to the Wabassee farm, where it strikes N. 15° E. and dips east. A mile to the east of this at Big Wabassee rapid, limestone and gneiss occur in fragments, and from this to the mouth of the Kiamika, where the river bends north again, the country is level and largely drift-covered with occasional outcrops of dark-weathering massive gneiss. For a mile above the Kiamika, small outcrops of gneiss are seen along the Lièvre, and thence to the Red farm the river is broad, shallow and full of sand bars, the country flat and without exposures, presenting a considerable area of good farming land. One mile above the Red farm a small exposure of limestone is seen at the Devils rapid. This is nearly vertical and filled with lumps of rusty gneiss and with scattered grains of graphite and chondrodite, and has a general strike of N. 20° W.

'From this place to the L'Orignal rapid, about eleven miles, the land is low, flat and sandy, with good soil and covered with hardwood timber. This belt of good land apparently extends for a considerable distance on either side of the river, and the rocks seen are small exposures of limestone and dark-weathering gneiss.

L'Orignal rapid.

'At L'Orignal rapid a band of rusty gneiss and limestone, with pyroxene and mica, strikes N. E. and dips N. W. 50°, and from this to Mountain farm, fifteen miles above, the rocks are dark-weathering gneiss and limestone, nearly always occurring together in small exposures, with a general strike of N. 20° E. and a dip to the west. The country in the vicinity of the river is nearly all flat, and the land is good and well timbered with hardwood.

Mountain farm to Rapide des Cèdres.

'From Mountain farm to Rapide des Cèdres, fourteen miles further north, the river is broken by frequent rapids, the rocks seen being principally gneiss boulders. At this point a band of limestone, about forty to fifty chains wide, strikes across the river and dips S. W. $<45°$ to 90°, holding mica, pyroxene and graphite and scattered lumps

of orthoclase and pyroxenic rock. The band is covered over largely by sand and the full extent cannot be seen. North of this to the Chaudière rapid, two miles distant, sand drift prevails. At this place ledges of red massive granite-gneiss, showing but small trace of foliation, appear, but with a general strike of north-west and a south-west dip $<45°$. One mile and a half north of this at the mouth of the Tapanee, a branch from the west, a small band of limestone is exposed.' This point marks the northern limit of Mr. Ord's exploration on this stream.

Although this portion of the river is beyond the limit of the map-sheet in question, the information concerning it is of importance as helping to explain the structure of the crystalline rocks in this northern area, and it has therefore been included in the scope of this report. From Mr. Ord's notes it is clear that the great stretch of comparatively level and drift-covered country, recognized on the upper portion of the Rouge and the Nation, extends westward to this area and that the development of limestone, so well seen nearer the Ottawa here almost disappears.

THE AREA BETWEEN THE LIÈVRE AND THE GATINEAU.

Route between the Lièvre and Gatineau rivers.

Between the Lièvre and the Gatineau several routes exist, along which the structure of the limestones and underlying associated gneises can be well studied. Of these the most southerly, north of the area intersected by roads, is by way of the Big Whitefish, Pemichangan and Thirty-one Mile lakes. This route presents, probably the best opportunity for the study of the rocks owing to the great extent of shore-line and rock sections exposed. The portages are mostly short and easy.

Portage routes to Whitefish lake.

From the Lièvre, Big Whitefish lake is reached either by Whitefish creek, half a mile long to the lower end of the lake, in the south-west corner of the township of McGill, or by a chain of lakes, connected by portages, the first of which leaves the river just below the sharp bend on lot 30, range II., Bowman, about five miles above High falls. The extension of the Portland apatite belt is seen in this direction, the mineral occurring on lots 30 and 31, range II., and 32 and 33, range III. The rocks seen on this portage to Rat lake and thence to Rouge lake, the next in the chain, are all gneiss and granite, with the exception of a small outcrop of limestone, coarse and crumbling, on the east shore of Rat lake. Masses of white granite, composed largely of felspar, are seen both on this and on Rouge lake, and on the latter two

Rat and Rouge lakes.

small exposures of the limestone appear along with quartzose rusty gray gneiss. On the north side of the lake the rocks are all gray and quartzose and dip S. 70° W. <75°. Indications of limestone are visible also in a belt of twisted calcareous gneiss which flanks the granite-gneiss of the hills to the north of this lake, from which and from the general synclinal structure it would appear that a calcareous band enters through the depression at the south-east angle.

Lac Croche.

A portage of a fourth of a mile leads to Lac Croche. Here two small bands of limestone are seen along with the usual rusty beds, and on the west shore the rock is gray and quartzose and strikes north with a dip to the east. On a small island the limestone and gneiss are cut by dykes of pyroxene and granite, and occasional pieces of the former are found in the pyroxene.

The north and east shores of this lake show several bands of limestone, separated by areas of gneiss, and dykes of white granite are frequent. No minerals of economic importance were noted in their vicinity, though small crystals of mica and scales of graphite were observed. Hills of gneiss surround the lake, but are thickly wooded. The portage from this to Whitefish lake is by a route from the south-west angle to a small lake, whence a carry of a mile over a ridge of red gneiss leads to the south-east corner of the lake.

Whitefish lake.

Whitefish lake has a length of about twelve miles from south to north, with a maximum breadth of nearly three. Near the centre of the lake a narrow neck of sand, underlain by limestone, extends from the east side and connects with a prominent ridge of gneiss and limestone which nearly divides the lake into two parts. The southern and larger portion contains a number of islands, the largest of which is two miles in length and is high and rocky. The northern part of the lake is narrow, but widens out near the lower end and there holds a number of islands. It discharges into the Lièvre river by a creek half a mile in length, flowing over limestone.

Road from Poltimore.

This lake is also reached from the south by a rough road leading from the village of Poltimore, through the southern part of the township of Bowman by way of Priests creek, to its southern end. Along this part of the lake the rocks are a mixture of grayish gneiss and limestone which have been cut by large masses of white granite and pyroxene. Near the south-west angle of the lake a deposit of mica in one of these pyroxene masses has been opened by a company from Ottawa, and a small quantity of the mineral extracted and shipped by way of the Lièvre to Buckingham. A portage leads from the west

Mica mine of Whitefish lake.

shore from a point opposite the Big island on lot 20, range XI., Hincks township, through a chain of lakes to the south-east corner of Pemichangan lake.

The eastern shore of Whitefish lake, at the south-east angle, is occupied by gneissic and calcareous rocks, the former often very quartzose, and the whole is penetrated by masses of white granite. Limestone and grayish gneiss, with occasional garnetiferous and reddish areas, show all along the eastern shore of the lake, similar in character to the rocks described along the course of the Lièvre. These are often much broken up, and intrusive masses of white granite are numerous. There are several series of opposing dips to the east and west, showing a folded structure, and the areas of limestone are much more numerous than in the portion between the Nation and the Lièvre rivers. Of the islands situated in this portion of the lake, the greater part are of reddish and gray gneiss, in places highly garnetiferous. Occasionally limestone bands occur, flanking anticlinals in the underlying rocks, and dyke-like masses of the white granite are common. The limestone bands are not traceable to any considerable distance, owing to sudden changes in the strike due to the numerous intrusions which divert the strata from their usual strike of N. 10° E., either through the agency of faults of greater or less extent, or through the thinning out of the beds in either direction.

Folded structure.

The west side of the lake along the southern half is for the most part occupied by limestone, from the northern line of the township of Hincks. These developments of the calcareous members of the system, on either side of the lake, appear to occupy synclinals, separated by the broad area of reddish gneiss which extends through the central portion. In these synclinals however, several subordinate folds are seen.

North of the bar and headland which divides the waters of the lake into two portions, the breadth is much less, the shores being from a half mile to a mile apart. The west shore, for several miles, is composed of highly garnetiferous gneiss often quartzose, in which a well-defined anticlinal structure is apparent, and the strike is nearly north-and-south. The northern extension of the limestone bands from the east side appears on the west shore resting on the east flank of the gneiss anticlinal to the west bay in the northern portion of the lake, and from this point to the outlet at Whitefish creek calcareous rocks for the most part occupy the west shore, showing however several minor undulations in which the underlying gneiss appears.

North end of Whitefish lake.

The eastern shore of the northern half of the lake is mostly gneiss. The presence at several points in the lake, both at the north and south ends, of intrusive areas of white granite is recognized, but with the exception of the pyroxene mass at the south end in which the mica deposit is situated the extensive mineral belt of the Lièvre district does not appear in this direction.

Portage route to Pemichangan lake.

The portage west from this lake to Pemichangan lake passes through several others, the principal of which are Bangatt and Green lakes. On a small lake just before reaching the latter, on lots 15 and 16 range XI. and XII., Hincks, rusty gneiss is seen on the east side and limestone on the west, as also at the outlet leading to Green lake half a mile distant. The rocks throughout this area are mostly limestone occurring in synclinals with separating areas of gray and rusty gneiss and with numerous masses of the white binary granite. Occasional bands of the reddish-gray underlying gneiss appear but the rocks as a whole represent the upper member of the system, rather than the lower or Fundamental Gneiss. The strike of the rocks throughout this section is north, but this is often changed through the agency of the granite intrusions.

Bangatt lake.

The western shore of Bangatt lake shows but little limestone, the rocks being gray gneiss and granite, but at the north end the limestone appears on both shores and extends northward into the valley of the creek which discharges this lake into Pemichangan. High hills of reddish gneiss rise on either side and an anticlinal structure is visible at several points.

Pemichangan lake.

Pemichangan lake lies to the south of Thirty-one Mile lake or Grand lake as it is also called, and is situated in the township of Blake. It is separated from the latter by a ridge of limestone across which there is a portage of ten chains. The outlines of Pemichangan lake are very irregular, long bays extending in different directions, and several islands occupy the centre, one of which has a length of nearly two miles. This lake discharges into Thirty-one Mile lake by a creek from the north-east angle.

Thirty-one Mile lake.

About the shores of this lake and of Thirty-one Mile lake to the north the usual arrangement of the upper gneiss and limestone is seen. The areas of the latter increase to the west, the Lièvre forming the eastern limit of the great Gatineau basin, but the usual strike of north to N. 10° E. prevails. The strata are thrown into a series of folds, the anticlines in the underlying gneiss being well displayed, and at times there is an intimate infolding of the two series, showing the strata to

be in places overturned. Intrusions of the white granite (pegmatite) are frequent and are especially well seen in connection with the limestone. At the point near the north end of Pemichangan lake on the east side, on lots 16 and 17, range VII., Blake, an intrusive mass of pyroxene and dark diorite is seen in which a small opening has been made for mica and apatite, but the quantity of these minerals seems to be small. Large areas along the shores on either side are occupied by limestone which strikes generally with the course of the lake, and a chain of islands extends at intervals throughout the entire length, showing gneiss on which the limestone rests on either side. The regular succession of the various strata throughout this area is strongly suggestive of their sedimentary origin. Many of the limestone bands in the synclinals are only a few yards in breadth, while others are exposed across their strike for nearly half a mile.

Up to this point, therefore, in our section west, it will be seen that the reddish gneiss is much more prominently developed than in the area to the east, and that the limestone and associated gneiss, where exposed, generally occupies synclinals in the former.

Portage route to Thirty-one Mile lake from Lac des Sables

The second portage from the Lièvre, from Lac des Sables, already referred to, shows a similar structure. This route was traversed by Mr. Ord, who says of it in his notes, 'the track from the north-west angle of the north bay in the latter lake runs in a north-west direction for about 100 chains to Hay lake. The surface is low and drift-covered and only one outcrop of gray gneiss is visible. On Hay lake a small outcrop of limestone is seen on the south side along with a little pyroxene. To the west a portage of half a mile leads to Lake Cochon on which also there is a small band of limestone having the usual north-east strike, and from this lake another portage nearly west for two miles leads to a small bay on the east side of Thirty-one Mile lake, a short distance north of the line of Blake township. On this portage a band of limestone occurs about midway, the debris on either side being reddish and gray gneiss. The lake band of limestone is met with about ten chains before reaching the east shore.'

Portage from Thirty-one Mile lake to Gatineau river.

From the west side of Thirty-one Mile lake a portage of three-fourths of a mile leads to Round lake at about lot 30, range VII., Cameron township, and passes over limestone with two small bands of reddish gneiss. Limestone occupies the greater part of this lake, as well as the islands in the centre, separated by outcrops of gneiss. The outlet from this lake is a creek about fifty yards in length, connecting with Rat lake, and the limestone extends all along and also occupies the eastern portion of the latter lake, which is divided into two parts con-

nected by a small narrow passage; but the west shore of the second portion is nearly all reddish granite-gneiss. Thence, to the creek discharging into the Gatineau, gneiss is seen all the way, and forms a broad area, but limestone again comes in on the lower part of the creek and continues to the Gatineau, a distance of half a mile. A belt of coarsely crystalline limestone shows on the Gatineau at the point where the creek from this chain of lakes joins it, and a rapid renders a short carry necessary. This point is about ten miles below the village of Désert, which is at the mouth of the Désert river.

The Gatineau river.

Descending the Gatineau much of the shore on either side is occupied by sand and clay deposits. The country is much more level than to the east, due to the greater superficial extent of the calcareous rocks, but occasional ridges of gneiss rise to elevations of several hundred feet. The soil in this direction seems to be well suited for agriculture, and the crops of wheat, oats and potatoes are excellent. A good carriage road, with a line of telegraph, extends along the river from the Ottawa to the Désert, and settlements continue northward for some miles further.

Six Portages.

At the bend of the river half a mile below the outcrop at the mouth of the creek just noted, rusty gneiss and quartzite show on the east bank. These are overlain a short distance down by limestones which dip east 55°. At the Six Portages post-office the gneiss also underlies the limestone on the west bank of the river, the strike varying from N. 40° W. to north, while the dip is east. Limestone also appears at the village of St. Gabriel, one mile further down, on the west bank of the stream, and from this down to the mouth of Bittobee creek occassional exposures of gneiss and limestone appear above the usual covering of sand and clay.

Portage routes from Bittobee creek.

At the mouth of the Bittobee which enters from the south, the Gatineau turns sharply to the west for about six miles, when it again bends to the south and flows through the townships of Wright and Aylwin. There is a road to Thirty-one Mile lake from the mouth of the creek and also a canoe route south by way of the creek and lakes Bittobee, Victoria and Little Whitefish and thence by a creek south to the Gatineau by which the great bend to the west can be avoided. The principal rocks on this route are limestone with separating anticlinals in the underlying gneiss.

Bittobee lake.

On the first of these lakes (Bittobee) the limestone appears on both the east and west shores, separated by an anticlinal in the gneiss, the opposing dips being east and west at angles of 65° and 75°. A second

anticline is seen on the west side of the lake in red and gray gneiss and masses of white granite and dykes of pyroxene occur in the limestone. A small deposit of mica has been opened at this place in connection with one of the dykes. Mica deposits.

Passing by a narrow channel into Victoria or Bass lake the shores are of reddish garnetiferous gneiss, strike, N. 10° E. dip E. $< 70°$. No limestone is seen on this lake. From the south end a portage of a third of a mile reaches Little Whitefish lake over a low ridge of limestone which forms the height of land at this point. Around the shores of this lake especially at the north end and on the west side outcrops of limestone are frequent in several bands separated by anticlines in the gneiss. The strike is constant, a little east of north, except where this is broken through the agency of granite intrusions. The rocks on the east shore are mostly rusty grayish gneiss. The discharge from this lake is south to the Gatineau by a creek along which the rocks are mostly limestone with granite. Victoria lake.

About midway on the east side a portage leads across to the Pemichangan about one mile and a half distant, passing over a high ridge of rusty gray gneiss and along a lake on the shores of which limestone is again exposed in a syncline. From the south-east angle of Bass or Victoria lake a portage also leads to Rat lake about twenty chains distant, over gneiss but meets the limestone before reaching the lake, whence the calcareous band continues along its south shore and crosses the lake in lot 30, range IV., Northfield. The strike of the gneiss and limestone here is N. 30° E. These bands are apparently the continuation of those seen on the lakes to the south. The gneiss of Victoria lake extends across and occupies the greater portion of the north-west shore of Rat lake or to the extension of the limestone bands on the south side. Portage route to Pemichangan lake.

From the frequency with which these limestone bands are repeated along the shores of the numerous lakes to the east of the Gatineau, and from the prevailing gray and rusty character of the gneiss throughout the area, it would appear that the upper or Grenville portion is most largely represented in this direction. The massive development of the underlying foliated gneiss, seen along the Rouge and the country to the west of that stream, does not so largely appear in this direction, and there is a greater development of the newer intrusives such as white granite, pyroxene, &c., but there are also areas of red gneissic-granite which are undoubtedly newer than the Grenville series, and which present certain features common to the Fundamental Gneiss. Numerous limestone bands.

The Gatineau below Bittobee creek.

From the forks of the Bittobee west, the Gatineau flows between drift-covered banks, and exposures of rock along the stream are few. About two miles below the forks, a heavy rapid, necessitating a portage of 10 chains occurs, over limestone and rusty gneiss, and a syncline is seen in the latter a short distance below the rapid. The underlying rocks on either side are of the same gray gneiss. To the north of this place on lots 14, 15, range D, Wright, several deposits of mica occur, one of which on lot 15, is of interest. It is in a vein of calcite associated with dark-green pyroxene and granite, the sides of the vein near the contact being thickly studded with mica crystals, some of which are of good size and of fine quality, though many of the crystals are affected by cracks and grains of calcite. The quantity of the crystals is however very great. The country rock in the vicinity is a grayish quartzose gneiss which forms a considerable ridge at this place. This mine has been recently worked extensively.

The St. Antoine mica mine.

Outcrops of limestone and granite with rusty gneiss also occur near the village of Gracefield in the township of Wright, at the point where the river bends again to the south, the dip being east $<40°$. These continue down the river to Aylwin while masses of reddish granite occur at intervals. Below Aylwin a small opening for mica has been made in a band of limestone, cut by a mass of white granite, but the crystals are small. On lot 22, range II., Hincks, about two miles east of Aylwin village, an important mica mine is situated. This is located in a pyroxene dyke which cuts the great belt of limestone and which is in turn cut by a dyke of granite. The mica here is very dark-coloured but the crystals are of large size and comparatively free from fracture. A large quantity of the mineral has been removed from this place.

Hincks mica mine.

Gatineau river, Aylwin to Paugan falls.

Below Aylwin for some miles the river is very rough, being broken by numerous heavy rapids and falls which necessitate frequent portages. The rocks along either side of the river are mostly limestone, though bands of gneiss occur at intervals, and masses of white weathering granite are frequent. No minerals of economic importance were observed on this part of the stream, but occasionally the rock is serpentinized and small veins of chrysotile were noticed. The stretch of broken water continues down to Paugan falls near the village of Low, and from this point down to the village of Wakefield (La Pêche) the current is smooth and the passage easy. Occasional ledges of limestone show along the stream and hills of reddish gneiss and granite rise on either side, but are more conspicuous to the east.

From Low station south, the section was continued along the line of the Gatineau Valley railway. North of this point, while many cuttings have been made the greater part of these are in blue clay and rock exposures are few. Southward the limestone is seen both along the river and the railway as well as in numerous ledges to the west, the strike generally being north, the dip varying from east to west. Hills of gneiss and granite rise at intervals, but a well-defined area in which limestone is abundant extends all along the valley of the Gatineau from about a mile above the village of Wakefield, having a breadth of several miles in the townships of Low, Aylwin and Cawood. This area will be again referred to.

Low to Wakefield.

The red granite comes in about a mile north of Wakefield village, and forms a large area to the south and west. Thence to the vicinity of Chelsea this is the principal rock seen along the railway. Much of this rock is clearly more recent than the limestone and associated gray gneiss with which it is associated, since it cuts both these in every direction. Both at the Cascades and between there, and Kirks Ferry, the pyroxenic rocks have a large development and important mines of mica have been worked for years. A short distance below Kirks Ferry a heavy band of limestone extends to the Gatineau from the direction of Old Chelsea, which lies in a syncline in the gray gneiss. Most of the cuttings on the railway north of Chelsea station are in sand, clay and gravel in one of which, about half a mile north of the station there is a deposit of marine shells. Thence to the junction with the Canadian Pacific railway near Hull, the country is occupied by heavy deposits of marine clay and no ledges are visible on the railway section.

Mica mine below Wakefield.

Marine shells near Chelsea.

THE UPPER GATINEAU.

The upper part of the Gatineau and several of its principal tributaries to the west, among which are the Désert and the Eagle with their connecting chains of lakes, as well as the Gens de Terre, further north, were examined by Mr. Ord in 1877. On the east side of the river he also examined the Baskatong creek and lake and thence continuing northward ascended the Piscatosin river and lake, whence by a portage, the Tapanee river, a branch of the Lièvre was reached, and a traverse made to the junction with the latter already mentioned.

The upper Gatineau.

Mr. L.R. Ord, explorations.

As a result of Mr. Ord's work we have now a very good knowledge of the character of the country in this direction, and as having a bearing on the structure to the south it is thought desirable to incorporate

the information thus obtained, though the greater part of the area lies beyond the limit of the map-sheet.

Désert and Eagle rivers.

Of the Désert, and its branch the Eagle, and of the country drained by these streams, Mr. Ord in his notes says: 'The Eagle empties into the Désert about fifteen miles from the junction with the Gatineau on lot 24 range VII., township of Egan. It flows from the west of south, draining several lakes in the townships of Church and adjacent townships in the county of Pontiac, and is narrow, shallow and swift. The country through which it flows appears to consist chiefly of sandy plains with occasional outcrops of dark-weathering gneiss. But few exposures of limestone are seen and these are of small extent. Of these the first is a fourth of a mile from the forks with the Désert, where, it is associated with rusty gray gneiss. A second band occurs a couple of miles furthur up stream having the same associations. The limestone here has a pink tinge and contains mica and pyroxene. For the next three miles the river is rough, flowing over boulders and occasional ledges of dark-gray gneiss, and with one small band of limestone at the end of that distance, beyond which to the junction of Hibou creek, the country is occupied mostly by drift with occasional outcrops of gneiss. One mile south of the Hibou and a fourth of a mile east of the Eagle a small band of pinkish limestone with pyroxene was seen.

Hibou creek.

'Hibou creek flows into the Eagle from the north-west. It is a small stream and for the first mile and a half is almost a continuous rapid, the river flowing across the strike of dark-weathering reddish gneiss. At this point known as the Eagle farm and about thirty chains south of the Hibou and twenty chains west of the township line of Church, there is a band of flesh-coloured limestone with crystals of apatite, mica and pyroxene, which has a north strike and dips east. The outcrop is small and the band is associated with a small exposure of gneiss, most of the country being drift-covered. From this to Pytongo lake, the river is a succession of small ponds with indications of gneiss, the adjoining country showing but few ledges.

Pytongo lake.

'Pytongo lake is a triangular-shaped sheet of water about four miles in length. It lies in a flat sandy plain with occasional mountains of dark-weathering gneiss. From this a portage route is followed through small lakes with short carries, over a sandy plain with gneiss hills to Désert lake. The rocks around Désert and Round lakes to the north appear to be all gneiss which underlies the sandy plain in this direction. In the Narrows between the two lakes a single fragment of limestone with scales of graphite was seen. Round lake discharges into the Désert which thence flows in a north-easterly

Désert and Round lakes.

direction over gneiss, till it takes its long course to the south. The country then becomes drift-covered with small exposures of limestone and occasional outcrops of gneiss to within a mile and a half of the Eagle, where on lot 35, range IV., township of Egan, a band of limestone dips east $< 45°$ and rests upon white, red and black-weathering gneiss.

'Below this to Désert village on the Gatineau, the rock outcrops consist of small exposures of limestone only. The large band of gneiss seen at the Désert church, crosses the Gatineau to the east bank, along which it continues to the Oiseau rapids, two miles and a half above the Désert, the west shore being occupied by the limestone. At this point the gneiss recrosscs the stream. It strikes north and dips east $< 45°$, and continues along the river to Joseph creek and portage, about lot 25, range A, and lots 23 to 28, range B, township of Aumond, where it turns off to the westward and the river flows over limestone as far as the Big Eddy portage on lot 7, range I., Sicotte. At this place the limestone also leaves the river and bends off to the west, and thence up to the Brulé portage on lot 19, Sicotte, the rocks along the river are red and gray-weathering gneiss. The Gatineau above Désert village.

Continuing up the Gatineau river, Mr. Ord further states, that at 'Mountain portage, lot 21, range I., township of Sicotte or two miles further north, a band of gneiss, which is presumably the same as that last noted, appears between two bands of limestone; the rocks are much crumpled and contorted with a local strike of W., dip S. $< 30°$. From this to lot 29, range I., Sicotte, one mile and a half distant, the river flows through drift banks, and just below the latter a band of dark and rusty-weathering gneiss occurs on the east shore striking N. 10° E. and dipping E. $< 45°$. This is associated on the west with a band of pink and white limestone, containing pyroxene and mica, with lumps of orthoclase, like the limestone at Mountain portage. Mountain portage.

'This band of gneiss is overlain by another band of limestone and crosses the river to the left bank again at the Reculon portage, about fifteen chains north. It again recrosses at the sharp bend of the stream about lot 48, range I., Sicotte, at the Bittobee chute, with a strike a few degrees east of north. From this the river continucs on gneiss for two miles, when the gneiss is overlain by a band of limestone which dips S. E. $< 35°$, whence to the Elbow, about lot 10, range A, Baskatong, the river crosses the strike of the gneiss. About thirty chains east of the Elbow, a narrow band of the limestone overlies the gneiss with a strike of N. 20° E. Reculon portage.

'From the Elbow to the Gens de Terre, the river flows through a flat, sandy country, with but few small rock-exposures. Above this

stream the same character of country continues, a small band of limestone being exposed in a small rapid, close to the forks of Baskatong creek, which enters from the east.

The Gens de Terre river.

'The Gens de Terre is a small stream emptying a chain of lakes to the north-west. It falls into the Gatineau at the line between concessions IV. and V., Baskatong. For a distance of twenty miles up this stream, to the Lépine farm, the country is flat and sandy. Four small rapids over gneiss occur in the first eleven miles from the Gatineau. At the Lépine farm the hills of gneiss begin to rise, and from this point the country is said to be very rocky.

Baskatong creek.

'Baskatong creek empties into the Gatineau from the east at lot 41, range VI., Baskatong, about one mile north of the Gens de Terre. It flows through a flat, sandy plain, and at a high stage of water in the Gatineau the current sets up stream into Baskatong lake, three miles distant. This lake has a length from north-east to south-west of four miles and a half by about three miles in breadth. At the south-east corner a bay extends for two miles further. There are but two islands in the lake, both of dark-weathering gneiss, and gneissic rocks occupy the shores of the lake on the west side with the exception of a point on lots 1 and 2, range IX., Baskatong, where a band of limestone occurs, holding black mica and green pyroxene.

Piscatosin river.

'The Piscatosin river enters this lake at its north-east angle. From this point southward the shore shows occasional ledges of dark-weathering gneiss, though considerable areas are flat, sandy and heavily timbered.

'The Piscatosin river is very crooked, flowing through a generally flat and sandy country, which shows but few ledges. Three bands of limestone occur between Baskatong and Piscatosin lakes, separated by bands of gneiss, the first of which is about one mile and a half from Baskatong lake, the second two miles further up stream, and the third one mile from the exit of the stream from Piscatosin lake. This latter sheet of water is five and a half miles in length, with an average breadth of about sixty chains. It has two bays running east, separated by a narrow point of land. The first exposures seen on this lake are on an island about forty chains north-east of the outlet, and consist of limestone with mica and pyroxene dipping N. $< 60°$. The associated rock is a dark hornblende gneiss. The limestone also appears on the west end of the point between the two bays, as also at the west end of the lake opposite. The shores of the long bay in the north-west corner of the lake, show dark-weathering gneiss, having a north-east strike, nearly vertical.

'From this lake, going northward, a stream fifty chains long, expands into Cocknagog lake, the prevailing rock being gneiss, with a small exposure of limestone near the outlet. Thence to the north-east the route continues along a chain of small lakes, expansions of the creek, with short connecting streams, for some miles. The country is generally level and sandy, with occasional outcrops of dark-weathering gneiss. Small areas of limestone are seen at two places, but owing to the topography of the country not being depicted correctly on any map, it is impossible to lay these down with any approach to accuracy. The limited areas exposed, however, as compared with that of the gneiss, tend to show that the calcareous rocks have very considerably decreased in volume in this section of the province, which is just north of the line between the counties of Ottawa and Montcalm. Cocknagog lake.

'From the head waters of this stream a portage of about 100 chains over the height of land, leads to Lake Tapanee. The rocks along the portage consist of gneiss, like that just described. This lake is five miles in length from north to south, with a bay extending to the east. Ledges of gneiss show at intervals around its shores with a general strike of east and west and a north dip $<70°$, and from its south end the Tapanee river flows through a generally flat country, with but few exposures, for nine miles, till it joins the Lièvre at the point indicated in the sketch of that river. The rocks seen on the lower part of the Tapanee are reddish and dark-gray gneiss, which dips N.W. Route to Lièvre by Tapanee river.

From the above description of this area by Mr. Ord, it would appear that the pyroxenic-bearing belt is but slightly developed in this direction, and that there is a very considerable extent of arable land, possessing, however, much of the sandy character seen about the upper portions of the Rouge and all the rivers westward. In ordinarily moist seasons these sandy soils produce excellent crops, both of cereals and roots, and the long established farms in connection with the several lumbering companies which operate in this district, have shown conclusively its productive character. The country, as a whole, is much less rugged than that within the first forty miles north of the Ottawa. Along the Gatineau, however, with the exception of the range of townships on either side, the surveys of the lakes and rivers with which the whole area is intersected are of the rudest kind, and of great portions of the country, it may be said, that there is nothing absolutely known as to the mineral conditions there present, except what may be inferred from the geological structure of the portions adjacent, which have already been examined and described. Character of country.

HULL, BUCKINGHAM AND WAKEFIELD DISTRICT.

Hull, Buckingham and Wakefield area.

The townships bordering upon the north side of the Ottawa, between the Lièvre and the Gatineau rivers, have, from their convenience of access, and from their great mineral wealth, been more thoroughly studied than any others throughout the area. Of these, Templeton, Buckingham, the eastern part of Hull, Wakefield and Portland West,

Important mines.

are particularly worthy of mention in this respect. In this area are situated the most important mines of apatite, graphite and mica yet discovered in Canada. Throughout their extent the same general development of limestone and gneiss of the Grenville series is seen, the latter predominating. Very considerable masses of clearly intrusive rocks occur, in the form of pyroxene, granite and greenstone, while several dykes of diabase rocks are also found. The settlements are, for the most part, confined to the river ranges near the Ottawa, though along the Gatineau and the Lièvre, these extend further north.

While outcrops of calcareous rocks are comparatively frequent it has been found very difficult at many points in this area to trace most of these to any great distance owing to various causes. Considerable areas are largely drift-covered, and throughout this portion of the Ottawa district there is a greater predominance of the igneous rocks which have exercised a marked influence on the regular distribution of the gneiss and limestone. It is doubtless to this development of the intrusives that the district owes much of its mineral importance.

Limestone bands.

In the eastern part of the township of Wakefield a well-defined band of limestone occurs, having its southern exposed limit in the township of Hull, where it is concealed by the clay covering. It can be traced north-easterly through the Wakefield lakes and the western part of Portland West, into the township of Bowman. It reaches the Lièvre at the High falls and thence extends for some miles up the course of that stream as already noted. Near the south-west angle of Bowman the band divides, the western arm following up the valley of Priest creek and lake, and thence by a chain of small lakes, on each of which it can be recognized, to the western side of the Big Whitefish lake in Hincks township. The separation of this band and its many deflections appear to be due to a large area of reddish granite, and large masses of pyroxene and greenstone occur in the vicinity near Priests lake and creek, where also important deposits of apatite are situated.

Anticlines.

A similar structure as regards anticlines in the gneiss is seen in this area to that which has been described throughout the districts to the

east and north. The limestone in its lower portion is interstratified with thin bands of rusty quartzose gneiss which gradually increase in thickness.

Buckingham and Templeton.

In the southern part of the townships of Buckingham and Templeton adjacent, the roads extend east and west along the concession lines and thus afford sections across the strike. Large deposits of clay and sand cover much of the surface to a distance of three to four miles north of the Ottawa river. Alternations of limestone and gneiss show along the road west from Buckingham to Donaldson lake on ranges IV. and V., as well as around the shores of the latter, but west of this to the road from Templeton village to Perkins Mill the calcareous rocks are rarely exposed and stratified gneiss with masses of reddish newer granite, often foliated, appears to be the prevailing rock. In this direction also, dykes of pyroxene rock, often of large size, cut the stratified gneiss at all angles to its strike and several valuable deposits of apatite are found associated with these, as at the MacIntosh and McRae mines. Along the valley of the Little Blanche, more particularly in the vicinity of Perkins Mill, limestone bands are seen. These are associated with serpentine which appears to be an altered condition of the pyroxene, rather than of the limestone, as the line of separation between the limestone and serpentine is strongly marked, and in the latter numerous small veins of chrysotile are developed. This area has been quite extensively worked, but most of the mineral is too short in fibre to be available for spinning, and the quantity too small, as compared with the great deposits in the Eastern Townships, to be worked with profit. The principal area operated in this direction is on lot 11, range VII., Templeton, about a fourth of a mile east of the main road near Perkins Mill. Similar serpentinous deposits occur a short distance south of the road west of Perkins Mill toward Letourneau lake.

Asbestus mine near Perkins Mill.

Templeton and Portland townships.

Around the shores of McGregor lake and along the chain of lakes to the north, comprising Big, Mountain, Portage, McArthur, Wakefield and several others in their immediate vicinity, the limestone bands are well exposed, but are often irregular, being frequently broken up by granite and diorite masses. They are however repeated at various points, both to the north and east, and several important mines of both apatite and mica are located around the shores of these lakes. In the township of Hull, however, there is a marked deflection in the strike of the gneiss and limestone along the east side of the Gatineau, due it would seem to the pyroxene and granite masses to the east, in which the Hull apatite and mica deposits are situated. Beyond these mines, however the strike of the strata in the south part of the town-

ship of Wakefield, along the river, resumes to a large extent, except where affected by local causes, its regular course of a few degrees east of north.

Hull and Wakefield.

In the townships of Hull and Wakefield, several well-defined bands of limestone can be recognized. The southern portion of the former township is largely clay-covered, and the first outcrop of the calcareous rocks is seen near the crossing of the Gatineau river at Wrights bridge. This band, which has a breadth of half a mile, can be traced north-easterly into Templeton township where it is interstratified with bands of rusty gneiss in its lower portion. A second band crosses the road to Wilsons Corner near the forks of the road on lot 6, range X., and pursues a course parallel to that just described. This is probably the continuation of that seen at the Forsythe iron mines on the west side of the Gatineau about two miles north-west of Ironsides. Yet another band crosses the river south of Kirks Ferry whence it continues south-westerly through Old Chelsea to the back road leading from Hull to Kingsmere, beyond which to the west the country towards the Ottawa river is covered by clay or by the rocks of the Palæozoic formations.

Cantley.

Northward from Kirks Ferry this band, after crossing the Gatineau continues north-easterly and crosses the road to Wilsons Corner near the Cantley post-office. Half a mile north of this another band comes in, and continues along the valley of Blackburn creek. This band is largely drift-covered.

Wakefield Cove, near Wilsons Corner.

Approaching Wilsons Corner large outcrops of crystalline limestone appear just to the north of the road along the line between the townships of Hull and Wakefield. This area is apparently split up into several bands, one of which with a north-east course follows the road to Pélissier's post-office and thence to Wakefield lake whence its extension to the north-west part of Portland West has already been indicated. In the northern part of this band the celebrated Wakefield cave is situated on lot 20, range II., Wakefield. From Wilsons Corner another band continues up the valley of the creek for more than a mile and then is cut off.

Limestone bands in Wakefield.

On the road west from Wilsons Corner to the Gatineau, a considerable band is exposed on lots 14 and 15, range I., Wakefield. It has a course to the west of north and has been followed south into range XV., Hull, beyond which its extension in that direction is doubtful. To the north-west it appears to continue along the course of Wilson creek and has a breadth of over one mile on lots 6, 7, 8 and 9, range

III., Wakefield, whence it continues to the north as far as range X., on Daly creek, beyond which it has not been followed. A band from the west of the Gatineau, crossing the river near Copelands Ferry, about two miles below La Pêche village, meets this area on lots 6 and 7, range III., the separating mass of rock being principally a red granite-gneiss; and another band enters the township of Wakefield from the south on lot 6, range I., which probably is also continuous to the band first described.

The St. Germain lakes.

Much of the interior of Wakefield township is practically unexplored except along the chains of lakes. Very few roads exist and with the exception of the St. Germain lakes at the head of the west branch of the Little Blanche river, access is very difficult. This chain which includes St. Germain, Marble, Dam, Clear and Newcombe lakes was carefully examined. A small band of limestone was observed at the south-east extremity of the first of these and at several points along the shore, but on all the others the principal rocks seen were reddish granite-gneiss and this rock apparently occupies a large portion of the township. Further north along the valley of the Gatineau river on the east side, exposures of limestone are very frequent, representing the eastern margin of the great Gatineau basin, and the exposed breadth in this area is not far from six miles. A northward prolongation of this area extends up the valley of Whitefish creek past Lake St. Mary to the Little Whitefish lake already described, while other portions are probably continuous north-easterly to the southern part of Lake Pemichangan. The portion of the township of Hincks and Denholm, lying between this area and Priests creek is apparently for the most part occupied by granite rocks.

Grenville series newer than the Fundamental gneiss.

The preceding descriptions refer principally to the distribution of the various bands of limestone and associated gneiss throughout the area pertaining to map-sheet, No. 121, and to that portion directly adjacent to the north. The structure of this portion is of especial interest, since it was upon the study of the rocks in the counties of Argenteuil and eastern Ottawa that the original views as to the structure and relations of the several members of the Laurentian were based. The area is also of special interest from the fact that we have here displayed not only the several divisions of the Grenville series, including the crystalline limestone and associated gray and rusty gneiss and quartzite, but also what was formerly regarded as the typical red dish and reddish-gray and hornblendic divisions included in the Fundamental or Ottawa gneiss. From the facts as to the structure of the two series just presented, it is evident that the rocks of the Grenville

series are decidedly newer than those of the Fundamental division. As for the numerous and often large areas of red granite-gneiss, many of these undoubtedly are of more recent date than either of the others, since they clearly cut both the gneiss and limestone. While in some points the newer granite-gneiss presents features similar to the Fundamental division, as in the foliation of certain portions, there is, over large areas, a marked difference in their aspects in the field. As regards the relative ages of the other intrusive or igneous rocks, such as the pyroxenes, greenstones and diabases it may be said that the first-named often cut the crystalline limestone, and is in turn cut by the binary-granites, which are generally light-coloured and composed largely of quartz and white felspar; while certain dykes, generally of small size but continuous for long distances, of dark-green diabase or trap are still more recent and cut all the preceding members.

Intrusive rocks.

Work of Prof. A. Osann.

Of these igneous rocks it may be said that they include many varieties, the details of which have recently been worked out under the microscope by Professor A. Osann, of Mülhausen, who spent several weeks in the area north of the Ottawa in 1899, and whose report is appended.

SEDIMENTARY DEPOSITS IN THE OTTAWA VALLEY.

Palæozoic formations of the Ottawa valley.

Between the limestones and associated gneisses of the Grenville series which, along the lower Ottawa at least we may regard as representing the newest members of the crystalline rocks, with the exception of the later eruptives, and the lowest member of the Palæozoic formations there appears to be a great geological break. Thus, if we regard the rocks of the Grenville series, and its equivalent, the Hastings series, which is found largely developed in the country south and west of the Ottawa river, as representing the lowest portion of the Huronian system, we find that the upper portion of that system, as seen in western Ontario, and also all the divisions of the great Cambrian system, have not been deposited in the Ottawa basin.

Potsdam sandstone the lowest.

Throughout the whole of the basin of the Ottawa and upper St. Lawrence rivers, the lowest member of the fossiliferous sediments yet seen is the Potsdam sandstone, which is now regarded in Canada as forming the lowest division of the Cambro-Silurian system. This division forms the base of the series along the lower Ottawa, as far west as the foot of the Chats falls, but has not yet been fully recognized at points further west. Above this place the lowest rocks of this series yet recognized belong to the Calciferous formation.

Arkose beds.

At a number of points throughout this district the basal beds of the Potsdam sandstone formation consist of a conglomerate, sometimes very coarse, and made up of pieces of the underlying gneiss and sandstone in a sandy and sometimes slightly calcareous paste. This rock fills up the inequalities in the old Archæan floor. As we reach the upper Ottawa, the lowest beds resting upon the gneiss belong to yet higher portions of the series, so that on the islands in the northern portion of Lake Temiscaming, the basal fossiliferous strata belong to the horizon of the Niagara formation.

Succession of formations.

In many portions along the lower part of the Ottawa river the succession of strata from the base of the Potsdam sandstone to the Medina is unbroken, and the several formations succeed each other in regular order. At several points, however, the whole series has been broken by faults, so that the geological structure is occasionally very complicated.

Horizontal character.

As a rule, however, the Palæozoic strata lie in a nearly horizontal attitude, or are disposed in somewhat shallow basins. Well-defined anticlines are seen throughout the area between the Ottawa and St. Lawrence rivers, but the inclination of the beds rarely exceeds five degrees, though occasionally this reaches an angle of nearly twenty. Near the faults, however, the inclination of the strata is sometimes as high as eighty degrees.

Boundaries of the Palæozoic rocks.

The fossiliferous sediments along the lower Ottawa have evidently been deposited in an estuary of the old valley of that river, which must have been well-defined at an early date and shortly after the deposition of the Grenville series. The northern limit of the Palæozoic sea is defined by the bold series of hills, which extend along the north side of the Ottawa from Ottawa city to St. Jérôme, situated to the north-west of Montreal, whilst the southern and western limit is indicated roughly by the areas of crystalline rocks, the eastern boundary of which can be followed from Arnprior to the city of Brockville, on the St. Lawrence river. These newer formations must, however, at one time have had a much wider extension than we find at the present time, since over a large area of the crystalline rocks to the west, scattered outliers of fossiliferous sediments occur as limestones of Black River and Trenton age, and also of Utica shales, throughout the upper part of the Ottawa basin reaching an elevation of nearly 800 feet above present sea-level.

Formations described.

The formations south of the Ottawa which are found in the accompanying map-sheet may be thus enumerated.

Utica shale.
Trenton limestone.
Black River limestone.
Chazy limestone and shale.
Calciferous dolomite.
Potsdam sandstone.

Lorraine and Medina.

In addition to these the Lorraine shale and sandstone are found in the area a little south of the present map limit, and certain outliers of red shales which rest upon the latter have been located and are assigned to the Medina formation.

Faults.

While as a rule these formations are in a nearly horizontal attitude or lie in shallow basins with low converging dips, at certain points they are intersected by heavy faults which have affected the strata over considerable distances. As these have exercised an important bearing on the distribution of several of the formations a short description of some of the more important may first be given.

Of these probably the most extensive is that recognized to the west of Rigaud mountain, which is an eruptive mass on the south side of Lake of Two Mountains already referred to.

Rigaud and Gloucester fault.

A reference to this fault and anticlinal will be found in the Geology of Canada, 1863, page 116, in which it is said to traverse the country south of the Ottawa river to a point some distance above Ottawa city. In places the dislocation of the strata is considerable, but sometimes the disturbance assumes rather the form of an anticline. This fault has quite recently been traced out in more detail and in the area immediately west of the mountain mass has affected the strata from the the Potsdam to the Trenton limestone in a marked degree.

Fault west of Ste. Anne de Prescott.

In the southern part of the township of Hawkesbury east, and a short distance west of the village of Ste. Anne de Prescott, limestones of Black River age are seen in the bed of the Rivière à la Graisse. They here dip to the south-west at an angle of about 10 degrees. Along the roads south of this place the Potsdam sandstone appears in nearly horizontal strata, so that the position of the line of dislocation is fairly well located. Much of the surface is covered with heavy beds of clay or sand and exact contacts are rarely seen.

To the south of this the Potsdam forms a prominent feature and is overlain southward by the Calciferous in regular order. Approaching the line of the Canada Atlantic railway at Glen Robertson the latter is seen at Glen Sandfield with a low dip to the south-west, beyond which there is an interval of clay with some Chazy drift which presumably indicates the presence of this formation beneath, since a short distance north of Glen Robertson heavy beds, representing the upper portion of the Black River formation are well exposed and in this outcrop several large quarries are located. Formations north of Glen Robertson.

The fault thus indicated has a direction nearly north-west, and the strata of the Trenton, Black River and Chazy on either side appears to have been displaced by a horizontal thrust in that direction for nearly nine miles. Displacement.

The extension of this line of disturbance into Russell, does not pertain to this area, but another line of fracture is seen a short distance east of the village of Rockland which has a direction to the south-east and probably meets that just referred to in the eastern part of Clarence township. By this, the formations from the Calciferous to the Trenton are broken across and displaced horizontally for nearly four miles. Furthur east along the lower part of the South Nation river there is also a sharp anticlinal fold in the Chazy and Black River formations and possibly a fault also, by which the limestones of the latter formation are thrown back to the north-west for about two miles. Rockland fault. Nation river anticline.

Nearer Ottawa and about two miles west of Greens creek another line of fracture is recognized which throws the strata of several formations from the Chazy to the Utica to the south for nearly forty chains. West of this again numerous breaks are seen but these pertain to the geology of the adjoining sheet to the south. Greens creek fault.

POTSDAM SANDSTONE.

Reference has already been made to the occurrence of the rocks of this formation in the area north of the Ottawa in a preceding chapter. In this direction the sandstones are the continuation of those which have been described in the south-west sheet (Montreal sheet) of the Eastern Townships series. They form a continuous belt to the south of the Archæan between the line of the Canadian Pacific railway from Grenville to Lachute, or rather from the line of the North river which flows between St. Jérôme and Lachute along the south flank of a ridge of crystalline rocks. They are well seen in a ridge and escarpment Potsdam sandstone. Lachute to St. Jérôme.

east of Lachute where they have a dip to the south of about four degrees, and are soon capped conformably by dolomites of Calciferous age.

St. Andrews mountain.

South of this between the Potsdam ridge and the Ottawa the surface is largely drift-covered, but is probably occupied by Calciferous sediments. The prominent ridge of granite east of St. Andrews possibly cuts, as in the case at Rigaud mountain, the Calciferous dolomites in which case it may be regarded as a recent intrusion.

Lake of Two Mountains.

On the north shore of the Ottawa below the mouth of the North river the sandstone again appears, but is here inclined towards the river away from the slope of the mountain at angles of 10° to 20°. Below this on the north shore the rocks are concealed by drift, but on the south side of the Lake of Two Mountains beginning above the mouth of the Rivière à la Graisse, and extending eastward towards Hudson, Potsdam sandstones are well exposed at intervals, and probably occupy most of this area near the river.

Rigaud village.

Their contact with the overlying Calciferous is seen near the railway bridge in Rigaud village where the dip of the latter is south-east at an angle of nearly 5° or directly towards the mountain which rises on the east bank of this river.

Outcrops in Alfred township.

West of this place along the Ottawa the Potsdam sandstone is recognized at but few points. It is seen near Lefaivre's wharf and on the road south of this place overlying the crystalline limestone of the Alfred outlier, and west of this place, it comes in on the shore a short distance above the ferry road opposite Montebello, where it is exposed for several hundred yards with a north-west dip at a low angle and is overlain by the Calciferous further west. On the north side of the river it is seen on a point about two miles east of Papineauville where there is a quarry in the sandstone and the strata here dip south at an angle of 4°. The sandstones at this place show the presence of the peculiar tracks which have been described from the sandstones of Beauharnois in the Geology of Canada, 1863, pages 103-106.

Quarry east of Papineauville.

Rockland mills.

Still further west, at Rockland mills, the lowest beds of this formation consist of coarse arkose or conglomerates made up of the debris of the underlying gneiss and limestone. This soon passes up into the characteristic sandstone which forms a low escarpment a short distance from the shore on the road leading from the wharf to the village, the dip being to the south-east at an angle of about 4°. This is in turn capped by or passes directly into the dolomites of Calciferous age.

These rocks do not again show on the south side of the Ottawa river within the limits of the map-sheet, but on the north side they rest upon the southern edge of the crystalline rocks at several points, notably on the Lièvre river near the railway crossing near Buckingham station and thence westward to the mouth of Wabassee creek which is about three miles east of Gatineau Point. At Buckingham the lowest beds are also conglomerate which fills hollows in the Archæan floor, but west of this, between the Lièvre and L'Ange Gardien station, the white sandstones are seen to the north of the railway in broad ledges till they are capped by the clay terrace. Buckingham.

West of Templeton station these rocks show on the branch line of railway leading down to Templeton wharf where they rest upon the gneiss about 700 yards south of the Canadian Pacific railway with a dip to the south and south-east of four degrees. They here form part of the escarpment which keeps to the south of the Canadian Pacific as far as the mouth of Wabassee creek when they disappear beneath the clay flat. Templeton.

The characters of the sandstone are well given in a section contained in the Geology of Canada, 1863, page 112, near Rigaud village. The section comprises a thickness of forty feet which represents the upper portion of the formation and the transition beds to the Calciferous dolomite. In this the lower thirty-three feet consist of interstratified beds of sandstone, sometimes calcareous but occasionally hard and vitreous with Scolithus markings, the upper member holding *Helicotoma* and *Murchisonia*. The upper seven feet consist of reddish gray magnesian limestone of the type common to the Calciferous over large areas. Rigaud section.

Fossils are rarely found in the Potsdam sandstone. With the exception of the markings styled *Protichnites* and other allied forms the only other form yet recognized is the peculiar fossil known as *Scolithus*. At the contact with the Calciferous, in what are known as the transition beds, a number of shells have been found which have been described in different reports. These occur in a rock which is partly siliceous and partly calcareous. The fossils are often silicified and by the weathering out of the calcareous portion are made prominent on the surface of the strata. Fossils.

CALCIFEROUS FORMATION.

The rocks of this formation are largely dolomitic in character. The upper beds as they approach the Chazy become shaly and the limestones are in thin beds. As a rule the strata are in a nearly horizontal Calciferous formation.

attitude but are thrown into low anticlines. The outlines of the formation closely follow those given for the Potsdam sandstone, but occasionally the latter are wanting and the Calciferous then rests upon the crystalline rocks.

In their distribution these rocks lie for the most part in close proximity to the Ottawa river. The most extensive development appears to be in the area south of the North river and between that stream and the Ottawa, where they have a breadth of several miles. They are well seen at Lachute near Wilson's paper mills in the west part of the village, in broad ledges, and also to the south of the Potsdam escarpment east of that place. In the direction of Grenville they are rarely exposed owing to the great extent of sand in this direction, but along the Ottawa between Grenville and Carillon they appear at intervals from beneath the Chazy shale.

Lachute.

Pointe au Chêne.

Further west they are exposed along the road west of Pointe au Chêne station on the Canadian Pacific railway. They here rest directly upon the rocks of the Grenville series, so that the Potsdam sandstone has not been deposited or has been cut out by a fault, no indications of which are visible.

Papineauville.

The country along the shore of the river west of this place is composed of clay. Between Montebello and Papineauville the dolomites are exposed on a small island about two miles east of the latter place where they dip south at an angle of 4°, and rest upon the Potsdam sandstone which is seen in the quarry near this place.

Black bay.

Above the mouth of the Nation river, along the shores of Black bay they occur in broad ledges with a low dip of 4° to 5° towards the river, and extend from this place to the village of Thurso where they are seen in a low escarpment on the road from the village to the wharf. They also show along the road east of Thurso where the road turns north along the line of the Gore of Lochaber, forming a narrow margin on the crystalline rocks north of the Ottawa for several miles.

East Templeton.

The most westerly outcrops of this formation in the map-sheet under discussion are about three miles east of Gatineau Point on the road from Wabassee creek to East Templeton where they show in broad ledges dipping with a low inclination towards the river and resting on the Potsdam of the Templeton escarpment. They are also seen on the road west of the Lièvre on the brow of the hill, but are soon concealed by sand at this place, but it would appear that the formation extends in a somewhat broad belt from the Lièvre to the mouth of the Gatineau river.

Cumberland and Rockland.

On the south side of the Ottawa they are exposed on the shore at Cumberland wharf, and extend inland for about 200 paces till they are overlapped by the Chazy shales. East of this they again come into view in the west part of the village of Rockland, near the road which turns south to Stewart's quarry. They occupy a large portion of the village, and are well exposed at intervals to the east limit where they are terminated by a fault which cuts all the formations upward to the Trenton. They here rest upon the Potsdam escarpment seen near the mills and are overlaid by the Chazy shales to the south.

Road west of Brown's wharf.

Their next appearance eastward is a short distance east of the South Nation river, where they appear along the road leading to Brown's wharf, and also on the shore overlying the Potsdam, already referred to near the Montebello ferry. They next come into view a short distance east of Hawkesbury, along the river, where they form the base of the Chazy, the area being traversed by several small faults. Near the mouth of the Little Rideau river, they have a breadth of about 200 yards and form the south side of the Ottawa here for some distance. Alternations of Calciferous and Chazy strata show along both shores of the river, thence east to Point Fortune and Carillon, the outlines of the formation being somewhat sinuous and the strata affected by faults of small extent. At the last-named place the dolomites are exposed along the shore at low water and dip south at low angles.

Hawkesbury to Point Fortune.

Rivière à la Graisse.

Near Rigaud mountain their presence has already been referred to. Above the village they show in the Rivière à la Graisse in low ledges for a fourth of a mile till they are concealed by clay, but on this stream, about three miles west, they appear in large ledges with a dip to the south-west at an angle of 5°, showing the extension of the formation over a considerable area west of Rigaud mountain.

Country south of Rigaud mountain.

It is probable that the Calciferous constitutes the greater part of the area to the south of Rigaud mountain, extending to the St. Lawrence and occupying the north side of that river from the Cèdres west to River Beaudette. The dolomites form a belt several miles in breadth lying to the west of Rigaud mountain, bounded on the north by the line of the great fault which brings against its outcrop on the north the Chazy, Black River and Trenton limestones successively across the southern part of the township of Hawkesbury east. West of this these rocks have not been recognized till the eastern extension of the great mass of the Rideau area is reached in the townships of Osgoode and Winchester.

CHAZY FORMATION.

The Chazy formation.

This formation has been divided into two parts, the lower embracing the shales and sandstones, the upper the limestones. There are about twenty feet of transition beds in the middle of the formation, where the limestones become interstratified with the shaly portion.

Grenville canal.

The shales have not yet been recognized on the north side of the Ottawa, east of the Gatineau, except along the portion between Grenville and Carillon. In this area the Grenville canal is cut in the sandy and shaly beds for its entire distance, and at Greeces Point, a short distance below the lower entrance to the canal, the contact between the Chazy and the underlying Calciferous can be well seen. Here the dolomitic usually buff-weathering limestones of the latter, are overlain by several feet of a fine conglomerate or coarse grit, resembling in some respects certain beds of the Sillery sandstone. These coarse grits soon graduate upward into greenish shales and sandstone, with thin partings of dark

Little Rideau.

limestone, which represent the lowest division of the Chazy. On the south side of the Ottawa, these shales south of the Little Rideau pass up into the limestones in which several quarries are located, notably that owned by Mr. Robert Ross. Nearer Carillon the contact between the Chazy and Calciferous is seen on the road along the north side of the Ottawa, about one mile west of the village, where there is an abrupt fold in the measures and a fault is also indicated.

Hawkesbury.

The shales of the lower part of the formation are well exposed about Hawkesbury and on the roads east and south. Cuttings are seen on the line of the railway to Glen Robertson near the small pond about half a mile south of the former village; and on the southern part of lot 10, near the line between ranges II. and III., outcrops of Chazy limestone occur to the west of the road leading to Vankleek Hill which are filled with the shells of *Rhynconella plena*. The country thence south to the road between St. Eugène and Vankleek Hill is largely drift-covered and outcrops are rare.

L'Orignal.

On the shore of the river between Hawkesbury and L'Orignal the shales are well exposed for several miles. South of the latter village they are also seen along the road to Cassburn, but a fault with a direction to the north-west crosses this road about one mile and a half south of L'Orignal and cuts out the Chazy limestone and a large part of the Black River formation, the upper beds of the latter being tilted to the south-west at an angle of 65° to 80° while the Trenton to the south has a dip of only 5°.

East of Vankleek Hill.

The Chazy limestones also appear along the road in East Hawkesbury between ranges IV. and V., and are well seen on a road south west from Barb post-office between lots 22 and 23. They here contain fossils and have a low southerly dip. Similar rocks show along the road to St. Eugène.

Outcrops west of L'Orignal.

West of L'Orignal the country is largely clay-covered for several miles. About three miles from the village several rock outcrops appear along the south side of the river road and in these a number of quarries are located. Some of these are in rocks of Black River and Trenton age, and the presence of the fault which was noted on the road south of L'Orignal is recognized in the tilted attitude of some of the strata. Outcrops of Chazy shales overlain by limestones of the same formation however appear, and these are highly fossiliferous. The rocks are nearly horizontal or with a low dip to the south and on a road leading from the village of Alfred to L'Orignal, known as the L'Ange Gardien road, Black River and Trenton limestones appear with low undulations.

Ridge south of Brown's Wharf.

Furthur west beneath the escarpment of Black River and Trenton limestones south of Brown's wharf, strata of Chazy age are recognized at its base dipping beneath the escarpment. The country in the direction south of the Ottawa is, however, mostly clay-covered, so that rock outcrops are rarely seen.

Clarence and Rockland.

Continuing west the Chazy shales come into view a short distance east of Clarence wharf and thence extend along the shore to the vicinity of Foxe creek below Rockland. They are here cut off by a heavy fault with a direction to the south which throws the strata horizontally for nearly four miles in the direction of Clarence creek. Between Clarence creek post-office and Rockland several faults occur, some of which have tilted the strata at high angles and the area is a good deal disturbed. The Chazy shales show along the road south of Rockland in the direction of Stewart's quarry and here pass beneath the Black River and Trenton escarpment to the south.

Faults.

Cumberland escarpment.

On the road along the south side of the Ottawa in the direction of Cumberland similar strata are seen at intervals at the base of the ridge a short distance to the south. At the latter place they form a somewhat bold escarpment to the south of the village and are succeeded upward by the limestones of the upper part of the formation and these in turn by the Black River and Trenton rocks. Thence westward the shales appear along the road as far as Greens creek, the limestones occurring in the escarpments south of the road, the whole having a low dip to the south or south-west.

Thickness of the formation.

Good opportunities for measuring the thickness of these two divisions of the Chazy are not afforded east of Ottawa. From observations made along the river west of the city, however it would appear that a thickness of not far from 100 feet must be assigned to the shales and sandstones, and about the same for the limestones with possibly about twenty feet for the middle or transition portion.

BLACK RIVER LIMESTONE.

Black River limestones.

The rocks of this formation appear in a belt varying in breadth from a few yards to over a mile. They overlie the Chazy limestones throughout their entire development, except where they have been removed by faults. One of the most important of these breaks is that situated a short distance east of Rockland where the band of the Black River on the west of the fracture is about four miles south of the continuation of the formation seen to the east in the direction of Clarence post-office.

Great displacement of the Rigaud fault.

In the eastern portion of the area the Black River outcrop seen in the northern portion of the township of Lochiel is separated from what appears to be its extension around the Calciferous and Chazy basin of Hawkesbury east, by a distance of about nine miles, the direction of the throw apparently being to the north-west. The formation southward underlies, throughout the entire Ottawa and St. Lawrence basin, the great development of the Trenton limestone, except in the township of Russell where it is affected by the line of the Rigaud and Gloucester fault along the Castor river, but this area lies to the south of the present map-sheet.

Outcrops of Black River limestones.

The Black River limestones can be well studied at several points. Among these may be mentioned the area east of Greens creek in an escarpment south of the Montreal road; several escarpments to the south of Cumberland village; Clarence creek, about four miles south of Rockland; outcrops along the road half a mile west of Clarence post-office on the Montreal road where they are affected by faults; the strata in the escarpment at A. Stewart's quarry south of Rockland; the South Nation river at Jessup falls about one mile from its junction with the Ottawa river; the north side of the escarpment from Brown's wharf to near the village of Alfred; Murray's quarry about one and a half mile south of L'Orignal, and se
the south of this in East Hawkesbury. The formation is important as furnishing some of the best building stones of the Palæozoic series. These are well seen near Glen Robertson on the line of the Canada

Atlantic railway, but the quarries at this place are a short distance south of the southern limit of the map-sheet.

The limestones are fossiliferous throughout. A large quarry in the upper portion of the formation is found at the crossing of a road over the Rivière à la Graisse on lot 15, range VII., Hawkesbury East. These strata contain *Tetradium fibratum* and other fossils characteristic of the formation, and have a dip to the south-west at an angle of 8° to 10°, apparently in contact with the Potsdam sandstone which shows along the roads a short distance to the south. Fossils.

TRENTON LIMESTONE.

The Trenton is an upward extension of the former division, the limestones passing into each other without stratigraphical break. The fossils are, as a whole, distinct, though in the Black River formation several forms occur which are common to both, but certain of the Black River forms are not found in the upper series. Trenton limestone.

The Trenton limestones have an extensive development in the area between the Ottawa and the St. Lawrence. They are thrown into low undulations which can be recognized at different places generally with low dips which rarely exceed 6° and are often much less. The thickness of the formation is probably not far from 700 feet, that of the Black River being probably not more than 100 feet. Undulations in the strata.

The Trenton limestones are extensively developed throughout the townships of Cumberland, Clarence, Plantagenet, Alfred, Caledonia, and Hawkesbury west and east. In the southern portion of most of these they are overlain conformably by the Utica shales which form the central part of the great Palæozoic basin. In the eastern part of the area the strata are affected in the same manner as those of Black River and Chazy age by the great Rigaud fault. They are well seen along the road from L'Orignal to Vankleek Hill, and south-west from the contact with the Black River formation at the fault near Murray's quarry they have a surface breadth till they are overlapped by the Utica of not far from eight miles. Relation to the Utica shale.

West of L'Orignal they are well exposed along the L'Ange Gardien road towards Alfred for about a mile, in low undulations. They occupy the upper part of the big escarpment south of Brown's wharf and thence are seen along the Nation river in the direction of Plantagenet village in large exposures, the rocks are filled with characteristic fossils of the formation, and the dip is to the south at angles of Alfred escarpment.

3° to 5°. Unless the formation is repeated by faults or by anticlines the dip thus recorded would give a thickness much greater than that already stated.

Anticlines and faults.

The presence of such anticlinal structure is however obvious at several points in this part of the basin. One of these apparently follows a course south-east from the mouth of the South Nation river indicated by the underlying Black River formation at Jessup falls already mentioned. A second is indicated by the presence of an intermediate basin of Utica shales extending across the western portion of Plantagenet north which probably is connected with the run of the Rockland and Clarence fault. Still another anticline from the eastern portion of Cumberland township extends into Clarence township near its central part and separates two other basins of the Utica, while yet others have been recognized in the district further to the south.

Outcrops of the limestone are not however numerous, owing to the great extent of clay and sand in this area, and the exact delimitation of boundaries must on this account be considered as sometimes conjectural.

The area about Ottawa and Hull, where the rocks of this formation are well exposed pertain to the map-sheet adjacent to the south.

UTICA SHALE.

Utica shale.

In the notes of Mr. James Richardson for 1853 the presence of several small outliers of the Utica shale was recognized in the area south of the Ottawa river in addition to the broad area of these rocks which form a large basin to the south of the Trenton just described. As the work at that early date consisted merely of the survey of several roads which traversed the district, much of which was then not open for settlement, the exact distribution of these outliers was not ascertained. Quite recently, however, detailed surveys have been made and their outlines have been determined as closely as the drift-covered character of much of the surface permitted.

Several basins.

In addition to the broad area of these rocks, which occupy a large portion of the townships of Gloucester, Russell, Cumberland, Clarence, Plantagenet and Caledonia, and extend southward to the Nation river and to its west branch, the Castor, two other well-defined basins, bounded on either side by Trenton limestones, were found.

These would appear to be side basins from the main area, extending to the north-west. The most easterly apparently comes to the South Nation river at the line between ranges IX. and X., of the township of Alfred, though as this area is largely clay-covered, its precise limit is not fixed. From the crossing of the Nation it extends in a narrow basin, indicated by a low flat through the eastern portion of Plantagenet North, with a breadth of rather more than a fourth of a mile. It should occupy a narrow strip between the villages of Curran and Plantagenet Springs and continue to the north-west, almost to the line between ranges II. and III., of the township, terminating on lot 14, where the shales are conformably underlain by the Trenton limestone. The black shales are well exposed on lots 12, 13 and 14 of ranges III. and IV., and represent the lower portion of the Utica formation. Plantagenet North basin.

The second and more westerly basin apparently extends north-west from the angle of the Nation river near the village of Pendleton to a distance of about fourteen miles into the township of Cumberland, the last outcrops in this direction being seen on lot 4, range II. This basin is separated from that just described by an anticline in the Trenton limestone in which also occurs the Rockland and Clarence fault. The Utica shales are well exposed in ranges I. and II., Cumberland, and in X. and XI., of Clarence, adjacent. The breadth of this basin is in places a little over a mile and it rests conformably upon the underlying Trenton. Cumberland and Clarence basin.

The portion of the main Utica basin found in the limits of the map-sheet is confined to the townships of Alfred, Caledonia and Hawkesbury West. The determination of the presence of the formation in Alfred is made from several bore-holes which have been sunk through the clay to a depth, in places of nearly 200 feet, the black shales being the underlying rock. In Caledonia the shales underlie the southern half of the bog or Caledonia flats, while the Trenton limestone is found in the vicinity of Caledonia Springs. Here there is also in places a great thickness of clay and sand. Bore-holes. Caledonia basin.

In Hawkesbury West, the Utica shales are exposed at several points. They reach to within about three miles of Vankleek Hill and rest apparently conformably upon the Trenton limestone in this direction. The structure of the Utica appears to be basin shaped, but there are probably low anticlines, the extension eastward of those seen in Clarence and Cumberland. Hawkesbury West.

The shales are usually black or dark-coloured. The lower half are strongly bituminous, the upper portion becoming lighter-coloured and Character of shale.

more sandy in character. These pass upward into the Lorraine shales and sandstone, which are more uniformly gray in colour and are not bituminous.

Thickness of the Utica.

The thickness of the Utica shale in this area has never been accurately ascertained. It has usually been supposed to be very thin and probably under 100 feet, but this estimate must be considerably increased. At a low dip of not more than 2° the volume in the western portion of the basin, south of Ottawa would be over 300 feet and though the formation as a whole is affected by low undulations, the thickness in the main basin will probably be not far from 350 to 400 feet, in this respect corresponding closely with the measurements at Montmorency falls below Quebec. The areas of the Lorraine formation south of Ottawa lie beyond the limits of the map.

SURFACE GEOLOGY.

Surface geology.

Throughout a great part of the district just described, large areas of drift in the form of sand, gravel and clay are common, and over certain portions extensive collections of boulders are found. Some of the latter masses are of large size as evidenced by the occurrence of single blocks from the crystalline rocks north of the Ottawa river, near Vankleek Hill, where in one case on the road thence to L'Orignal a block of granite measures twenty feet by fifteen and is four feet out of the ground. On a road north from Glen Robertson in the north east part of the township of Lochiel, numerous huge masses are scattered over the surface. These comprise granites, anorthosite rocks, quartzites, etc., one block of the first named being thirteen feet by ten, and three feet out of the ground.

Large boulders.

Boulders ridges.

Along the flanks of the granite ridge east of St. Andrews village the blocks of anorthosite are numerous and some are of large size. To the south of the Ottawa also these boulders occur frequently in the form of ridges, of which one is conspicuous just north of the village of Ste. Anne de Prescott, and is made up of immense blocks of granite, anorthosite, quartzite, crystalline limestone, etc. They are moreover widely distributed over portions of the area north of the St. Lawrence river.

Marine clays and sands.

The clays and sands were undoubtedly deposited under marine conditions since they both contain at various points an abundance of marine organisms, such as shells, the remains of seals and fishes, sponges, &c. The localities where these fossils are found are widely

scattered, so that while it may be supposed that all the clays in the district at the same general level are of the same origin the evidences of this are only obtained at rare intervals. Thus along the Ottawa river at the mouth of Greens creek, at Besserers wharf about one mile below and at one mile east of Cumberland wharf, an abundance of clay nodules are obtained which contain the skeletons of *Mallotus* as well as shells, leaves and other remains around which the concretions appear to have formed, below this to Hawkesbury, although the clays along the shores were carefully examined, marine remains were rarely found in them. It is therefore conclusive that the absence of these does not necessarily indicate a different origin.

Fossils of Greens creek.

To the north of the Ottawa great deposits of sand and clays are seen along all the streams flowing south from the height of land. These deposits extend north for many miles. The clays occupy the lower levels and are frequently exposed along the river banks by the cutting down of the channels through the great overlying beds of sand which are widely spread over the surface around their upper waters.

Clays and sands north of the Ottawa.

At many points these deposits are now arranged in a series of terraces of which four at least can be readily recognized along the upper part of the Rouge and the Lièvre rivers. The underlying rocks are thus concealed over large areas by the great deposits of drift, but ridges frequently protrude from the otherwise drift covered plain.

Terraces.

Along the lower Ottawa to the south-east of the North river between the villages of Lachute and St. Jérôme, several well-defined terraces are exposed. These consist of clay, sand and gravel, the upper benches frequently composed of the latter, and at a point about four miles south-east of Lachute two artesian wells were sunk several years ago which have yielded a supply of the purest water. These wells were put down near the foot of a sand and gravel terrace the top of which is about fifty feet above the level on which the wells are located. Of these wells one reached a depth of eighty-three feet, while the other was sunk to a depth of 120 feet, the underlying rock not being reached in either case. This would give a thickness for the drift deposits in this area of not far from 200 feet showing a depression which probably represents an old channel of the Ottawa which was some feet below the present river bottom. No rock ledges appear in the area between the ridge east of St. Andrews and the Calciferous beds to the south-east of Lachute village.

Lachute to St. Jérôme.

Artesian wells.

The construction of the Gatineau Valley railway, along the west bank of the Gatineau river, has enabled us to study the clay deposits

Gatineau Valley railway.

of this district. A great number of cuttings in this material are seen along the line for more than forty miles north of the Ottawa, some of which show walls nearly 100 feet in height. These have been carefully examined as far north as Kazubazua station where the country becomes covered largely with sand deposits.

Marine shells near Chelsea.

The greater part of these cuttings show no organic remains whatever. At a point half a mile north of Chelsea station, however, a bed of marine shells is seen at the contact of sand and gravel with the clay, from which several species have been obtained. The elevation of this place is 395 feet above sea-level.

Shells near Cantley and McGregor lake.

To the east of the Gatineau in Hull township on the road from Cantley to Wilsons corner and about half a mile north of the post-office at the former place, clay banks in a small brook showed quantities of marine shells among which were recognized *Saxicava rugosa, Macoma fragilis and Leda arctica*, with some foraminifera. The elevation of this spot is about 350 feet above the Ottawa by aneroid or about 465 feet above sea-level. At the outlet of McGregor lake, two miles north of Perkins Mills, near the road crossing, shells of *Saxicava* are very abundant and *Macoma* are rare. The elevation of this point is given as 458 feet above sea-level.

Drift of the upper Gatineau.

From the elevations along the Gatineau railway it is probable that all the clay deposits there seen have the same origin. It would appear therefore that the estuary of the Ottawa extended over a very wide area at the time when these deposits were laid down. These clays certainly extend northward to an elevation of more than 700 feet where they are covered by great accumulations of sand. Along the upper part of the Gatineau, the observations of Mr. James Richardson, during his trip from the St. Maurice to this river and his descent of the latter stream, shows that this character of drift-sand continues to the height of land between the two streams which he places at an elevation of about 1,500 feet. That this generally level and sand covered country extends over much of the area north of the Ottawa has been stated by all observers who have traversed the district.

Height of land.

This great overlying mass of drift-sand appears to be devoid of organisms, at least in so far as yet ascertained. It would appear to owe its origin however to the agency of water and should represent the decay of the granitic and gneissic rocks which form the chief geological feature of the district.

Good soils.

Many of these deposits are loamy in character and as a consequence furnish valuable lands for agricultural purposes. Of this

DEVIL'S PLAY GROUND, (LA PIÈCE DE GUÉRÊT) RIGAUD MOUNTAIN, QUE.

character are portions of the area along the Gatineau and the rivers both to the east and west. Large farms in connection with the various operations in lumber, for which this district is celebrated, have been successfully worked for many years, and have clearly demonstrated the fact that in ordinary seasons, much of the land, more especially in the valleys, is of great agricultural value. There are however large areas of apparently almost pure granitic sand, forming plains which are comparatively valueless for this purpose.

Clays north of the Ottawa.

Along the north shore of the Ottawa clays are found to an elevation along the hill sides of at least 500 feet. These higher clays have as yet yielded no fossils, but near Grenville in the bank of the river these are found. They have been described in the Geology of Canada, 1863, page 917.

Boulder beach of Rigaud mountain.

One of the most interesting deposits of water worn stones, forming an old beach, is seen on the north-west flank of Rideau mountain. It has been described in the earlier publications of the Geological Survey, and a brief description is given in the volume just mentioned on page 896. They occur at an elevation of about 550 feet above sea-level by aneroid taken by Mr. R. Chalmers* and are seen in a series of bare patches of oval shaped and rounded boulders ranging in size from two inches to fifteen inches in their longest axis. From the fact that no vegetation grows over much of their surface it would seem that they rest at this point on a rocky base. At the present time the deposit consists almost entirely of the water worn stones, all the sandy portion of the deposit having been washed away and deposited nearer the foot of the slope where these sands are conspicuous. The deposit has been excavated to a depth of more than ten feet and maintains the same character throughout. The rocks are for the most part of the porphyry of the west side of the mountain and a few of quartzite are associated. To the south-west this deposit can be traced for a couple of miles, and is crossed by the road leading south to the village of Ste. Marthe on the western spur of the hill, where it is covered with a scanty growth of small trees and bushes. No trace of it is seen on the south side of the mountain, and it appears to indicate the remains of an old beach during the period of submergence of this area. This deposit has been referred to in the report by Mr. R. Chalmers†.

Striæ.

Ice markings are found at several points throughout the area. They indicate a movement in several directions throughout the Ottawa basin, and the direction of the striæ, as given in the lists published by

* Annual Report Geol. Surv. Can. vol. X. (N.S.) 1897, p. 61 J.

† Annual Report Geol. Surv. Can. vol. X. (N.S.) 1897, pp. 60J and 60A.

Ice movements.

Mr. R. Chalmers in the report just quoted, ranges from east and west to south. It is not deemed necessary to repeat these lists in this place. It would seem that there were at last two phases or periods of glaciation and a third series of markings were probably produced through the agency of floating ice, which apparently moved westward along the present course of the river in an almost opposite direction to that taken by the first Laurentian glacier which seems to have closely followed the contour of the Ottawa valley. The lists of striæ will be found in Mr. Chalmers' report, vol. X., pp. 29-39 J.

ECONOMIC MINERALS.

Economic minerals.

Among the minerals of special economic importance which are found in the district just described may be mentioned apatite, mica, graphite, asbestus and iron. Baryta also occurs in veins at several points and the felspar and quartz which make up the greater portion of many of the masses and dykes of white granite have been found to be of sufficient purity in some cases to be economically worked for the manufacture of glass and pottery as well as of porcelain. In this connection may also be mentioned kaolin, of which at least one deposit of very fine quality is known in the township of Amherst.

In addition to these, certain portions of the district are celebrated for yielding a variety of minerals most commonly associated with the crystalline rocks such as pyroxene, tourmaline, zircon, sphene, scapolite, &c., which are of considerable mineralogical importance and often a source of considerable revenue. The crystals are frequently of large size and in considerable quantity, so that this area has in this respect become celebrated. Certain other minerals have also recently been found in this district which possess certain features fitting them for decorative and ornamental purposes and some of these have yielded gem stones of considerable value.

APATITE.

Apatite.

The occurrence of this mineral north of the Ottawa was known for some years before its economic value was ascertained. The first reference to it was made by Lieut. Ingalls, in the Transactions of the Lit. and Hist. Society of Quebec, in 1829. It was subsequently referred to by Dr. T. S. Hunt, in the Geology of Canada, 1863, page 461, as present in certain rocks in the township of Hull, as also its occurrence in the township of Ross ; but its extraction for export did not commence till

the year 1871–72, or nearly ten years after it was first mined in the province of Ontario, in the townships of Burgess and Elmsley.

The history of the industry has already been fully given in a report on 'the Mineral resources of Quebec'* but certain features in regard to its mode of occurrence and distribution having a more direct bearing on the economic aspect of the question may here be stated.

Igneous rocks.

The presence of various kinds of igneous rocks in the gneisses and limestones of the Grenville series has already been referred to in the preceding portion of this report. These are of several kinds and include syenites, granites, anorthosites, porphyries, pyroxene rocks, binary granites or pegmatites, trappean or diabase rocks. That these are of different ages as regards their period of intrusions is manifest from their relations to each other. Thus the syenite mass of Grenville clearly cuts across the diabase dykes which can be traced for a long distance through the townships of Petite Nation, Grenville and Chatham, while these diabase dykes just as clearly intersect masses of pyroxene and binary granite. Of these several intrusive or igneous rocks it may be said that some of them have exercised a manifest influence upon the occurrence of some of the economic minerals, while in the case of others such influence is not apparent. With the pyroxene rocks are associated apatite, mica and sometimes graphite and asbestus, but with the granites the apatites do not appear in so far at least as has been observed, though mica is frequently an associated mineral in pegmatite dykes. The pyroxene is usually of some shade of green but in certain areas, more particularly in the limestone formation, which is occasionally a dolomite, the colour of the pyroxenite becomes whitish or yellowish-white though its dyke-like character is sometimes maintained. In these cases it is often difficult to distinguish in hand specimens between the pyroxenite and the crystalline limestone.

Their associations with economic minerals.

Pyroxene rocks.

Pegmatites.

The white granites or pegmatites appear in places to have a much more widely extended development than the pyroxene rocks. They have been recognized at a number of points throughout a very large area, both to the north and south of the Ottawa. They generally contain a small quantity of mica which however is recognized only on close examination. They frequently appear to intersect the pyroxene and therefore should be of later date as regards their intrusion.

Mineral belt of the Ottawa district.

The pyroxenic rocks with which the deposits of apatite are most closely connected, are, in the country north of the Ottawa, to a large extent, confined to the area between the rivers Lièvre and Gati-

*Annual Report Geol. Surv. Can. vol. IV. (N.S.) 1889.

neau, and for a few miles on either side of these streams. Their principal development does not extend north of the Ottawa in most cases to a greater distance than twenty to thirty miles. They occur not only as masses, often of large size, but as dykes sometimes bedded with the strike of the gneiss or limestone but also sometimes cutting across the stratification of these. From the bedded aspect of some of these rocks the pyroxenes were for many years regarded as sedimentary deposits similar to the limestones, and as constituting an integral portion of the gneiss and limestone formation.

This supposition is supported to some extent by the presence in certain portions of a gneissic structure, developed presumably through the same agencies which produced the foliation of the granite and anorthosite. Masses of pyroxenite also occur in the township of Hull, west of the Gatineau and in Wakefield and Masham. The extension of the pyroxene belt south of the Ottawa is seen in the townships of North Elmsley and Burgess already described in earlier reports. It is, however, impossible to connect these widely separated areas on the north and south, since the valley of the Ottawa which separates them is occupied by the extensive development of the Cambro-Silurian strata already described.

Relations of the pyroxene with the gneiss.

Character of the intrusive in the Lièvre district.

In the study of the pyroxenic rocks north of the Ottawa, several features observed are worthy of notice as having an important bearing upon the occurrence of deposits of apatite. Thus in certain places, such as the area of the phosphate bearing rocks in Portland west, extending from Ross Mountain into the VIIth range immediately west of the Lièvre river and northward for several miles, the intrusive pyroxenic rocks are intimately associated with the gneissic portion of the upper or Grenville series, portions of the gneiss appearing as if caught and held in the mass of the former.

Ross mountain mine.

At the Ross Mountain mine, High Rock, Crown Hill and others in this belt, the relations of the pyroxene rocks with the quartzose gray gneisses and of the apatite to the pyroxene can be well seen. At the former place the gneiss has a strike of N. 5° to 70° W. the dip near the summit of the hill being southerly at an angle of 65° to 70°. Openings for apatite occur at a number of places along the south and east side of the hill which has an elevation above the river of not far from 700 feet, as well as along the summit of the mountain. At all these places dykes of hard dioritic-looking rock are seen, sometimes traversing the gneiss along the planes of stratification, but frequently cutting the gneiss transversely to the strike. The dykes are generally of some shade of greenish-gray, at times with a peculiar bluish or

purple tint, resembling in this respect some of the anorthosites of the area north of St. Jérôme, and as a rule these are devoid of gneissic structure. In these cases the apatite occurs in the mass of the pyroxenic rock, not as a regular vein but generally as small bunches of the mineral. Near the crest of the hill a band of the mineral in a dyke has a course of N. 5° E. across the strike of hornblende gneiss. The apatite masses occasionally give off small spur-like veins from the side of the deposit, the containing gneissic rock having a strike of W., the dip being vertical.

Occurrence of apatite in pyroxene.

A deep pit at the summit of this hill shows the same greenish-gray pyroxene rock from which apparently a large pockety mass of apatite has been extracted. A small included mass of calcite holding crystals occurs in the pyroxene, but no regular calcareous strata are visible in the vicinity. In the banded gneiss no phosphate is seen. Just west of the pits on the summit of this mountain, black hornblende gneiss with quartzose bands strikes north with a dip to the east of 70° and contains small dykes of diorite which run with the lines of stratification.

In places, judging from the character of the excavations which are left after the removal of the mineral, the apatite would appear to occur frequently in chimney-like masses, the sides of the excavation, which is often several yards in diameter, showing little or no trace of the mineral.

The Crown Hill mine.

At the west pit of the Crown Hill mine, which lies to the north-west of Ross mountain and adjacent to it, a dyke of dioritic-looking pyroxene cuts across grayish hornblendic, sometimes garnetiferous gneiss. This gneiss strikes N. 80° W., and is nearly vertical. The course of the dyke is almost north-and-south, with a dip to the east of 60°. The same dyke with the same direction can be seen in the adjacent pit. The apatite here has been taken from the dyke and the remains of the deposit can be seen in the pyroxene near the contact with the gneiss.

Dyke rocks.

Crossing a ridge to the east of this place the main workings of the Crown Hill are reached on the east side of a swampy flat. The gneiss, rusty and quartzose in places, strikes N. 80° W., is nearly vertical and is cut by a dyke of the usual pyroxenic character. The gneiss here overlies the pyroxene in the upper part of the pit, and is much broken up as if thrown out of its regular position by the action of an intrusive mass. In this the apatite occurs as a series of impregnations or irregular masses, extending inward from the contact with the gneiss for eight to ten feet. The bluish-purple felspar is well seen in the

Apatite.

pyroxenite at this place also. The apatite here does not present any of the features of a bed nor of a well-defined vein, there being neither foot or hanging walls in the ordinary use of the term. The mineral occurs in the form of pockety deposits, in the pyroxene, connected apparently by smaller strings near the contact with the gneiss, and some of the pockets have yielded several hundred tons.

Pocket character.

Ascending the railway track (now taken up) to the summit of the ridge, several pits are found along the slope of the hill south of the company's offices. Here the presence of three distinct dykes is seen, viz., the pyroxene cutting the gneiss, the whitish pegmatite granite cutting the pyroxene, and both of these cut by a three foot dyke of dark-green diabase. The apatite deposits here occur apparently as pockets or chimneys, which have been mined to a considerable depth, and are connected by small irregular vein-like deposits. Along the sides of the pyroxene, near the contact with the gneiss, the remains of the apatite can be seen in the shape of small patches or impregnations of the dyke. The gneiss here has a dip to the west at a high angle.

High Rock mine.

On the road leading thence to the High Rock mine interstratified gneiss and quartz rock occur. The strike is generally N. 60° W., and the dip is to the north-east at an angle of 80°. These are frequently cut transversely, and in places almost at right angles to the strike, by dykes both of pyroxene and pegmatite.

At the High Rock mine, the summit on which the principal workings are situated, is about 700 feet above the river at its foot. The pyroxene and granite dykes are visible in all directions, both at the surface of the hill and in frequent exposures along the sides down to the base. Cuttings have been made in the pyroxenic masses at many points, the lowest workings on the south side of the mountain being about 400 feet below the summit. In places the granite intersects the pyroxene and frequently these intrusions are so numerous that the gneiss, which is the country-rock, occurs as narrow bands or irregularly shaped areas, often of very limited extent.

Apatite in pyroxene.

The apatite in all cases occurs in association with the pyroxenic mass, and the lowest workings are apparently quite as productive as any near the summit, though there is no well-defined vein structure apparent. At the mine near the base of the hill, the apatite occurs as great pockety deposits, often of many hundreds of tons in extent, but varying in size in different portions of the pyroxene mass.

Mode of occurrrence.

In the case of the dyke of apatite-bearing rock possessing much breadth, the mineral is found usually in close proximity to the contact

with the associated gneiss, and frequently both margins of the dyke are apatite-bearing in this way, while the central mass of the pyroxene is almost entirely barren. In narrow dykes carrying apatite, the whole mass is usually extracted and the mode of occurrence is then not so easily seen. At the Star Hill mine, about one mile distant from High Rock to the north, a deep pit has been sunk in greenish pyroxene, with a reddish and white felspathic dyke. The apatite here is also in the outer zone of the pyroxene, which is clearly intrusive in the rusty and gray quartzose gneiss, the latter striking N. 60° W. vertical. At this place the gneiss is garnetiferous in the vicinity of the pit, and is also cut by a dyke of pegmatite. The pyroxene dyke is more nearly along the lines of stratification of the gneiss, but both are clearly of later date.

Star Hill mine.

The Central Lake mines are situated about two miles north of the last-named on the north side of Central lake. It is also in the extension northward of the apatite-bearing belt, which begins with Ross mountain. The country-rock is a grayish quartzose gneiss, having a strike nearly north-and-south. Near the pits to the west and below them on the slope of the hill, a band of dark fine-grained hornblende gneiss, with a band of limestone, strikes north and dips east $<75°$. The pits are sunk in a mass of pyroxene, as at High Rock, and the apatite occurs generally along the sides of each pit, with crystals of mica, at the contact with the adjoining gneiss. The deposits of apatite widen out into large pockety masses, which continue at either side of the pit into narrow veins or strings. At the south pit the gneiss is cut across the strike by the cross-dyke of pyroxene with which the apatite is associated, and this presents the aspect of having pushed the gneiss in contact out of its regular course. Dykes of granite intersect the pyroxene at this mine, and indicate from their relation a later period of intrusion.

Central Lake mine.

Character of the apatite deposits.

At the High Falls mine, one mile further north, and the most northerly mine worked in this belt, the gneiss which forms the country-rock is overlain about five chains east by a broad belt of limestone which extends eastward to the Lièvre river and can be traced for several miles north of this place. The apatite here also occurs in irregular pockety masses in a pyroxene rock, which is clearly intrusive, in that it traverses the gneiss nearly at right angles to the lines of stratification. There is no indication either of a bedded or vein-structure at this place, but the mass of the pyroxene appears to be impregnated with the apatite in places, and on the sides of the pit small patches are seen disseminated through the dyke.

High Falls mine.

On the east side of the Lièvre, in the township of Portland East, there are a number of valuable mines of this mineral which have been extensively worked and are of special interest from the depth at which the apatite has been found in profitable quantity. Among these, probably one of the most interesting and important, as illustrating the method of occurrence of the mineral, is the North Star, situated near the west shore of Tamo lake, on lot 18, range VII. This mine presents certain features which render it peculiarly favourable to the study of the apatite deposits, since it has been worked to a reported depth of over 600 feet in the principal shaft. The location is on the crest of a gneiss ridge, 600 feet above the Lièvre river, which is about three miles distant to the west. On the south flank of the ridge or hill on which the mine is situated, dykes of greenish pyroxene rock cross the road. These dykes carry apatite, and they cut reddish-gray gneiss, which has a strike N. 35° W. and a dip N. 55° E. $<60°$. Ascending the hill, a large dyke of pyroxene has a course of nearly north-west and south-east almost vertical.

North Star mine.

The gneiss a short distance to the east is hornblendic and much injected with quartz and felsite veins. It is well banded and strikes N. 5° W. and dips east $<$ 60° to 80°. At the south pit, before reaching the hoisting works, the intrusive character of the pyroxene is well seen. It has the aspect of a chimney-like dome which has thrust up the gneiss in contact, the strata of which bend round the pyroxenic mass. The apatite in this dyke occurs near the contact with the gneiss. The dyke can be followed nearly along the stratification of the containing gneiss for several hundred yards and is opened by a series of pits and cross-cuts in all of which this mode of occurrence of the apatite can be recognized. In the upper part of the main or deep pit, two bands of apatite are seen, one on each side of the dyke, forming an irregular deposit which gives off small branching spurs into the adjacent pyroxene. These two bands have been followed downward to the lowest or 600 feet level, the quantity of apatite apparently being as great in the bottom of the shaft as in the upper levels, but varying as all these deposits do, owing to the irregular nature of this formation.

Contact character of the apatite.

In the north pit the structure is that of a dome-shaped mass of pyroxene, carrying apatite irregularly disseminated, which has been forced upward through the gneiss, a capping of the latter being seen along the edge of the pit on the east side. In some of the pits near the outer margin of the dyke, crystals of dark mica occur. From the continuity of this dyke and its extension downward to such a distance the theory has been put forward by some that it is a true vein forma-

tion. If so neither hanging nor foot-walls are found, but from the fact that the apatite occurs, in most cases at least, within a few feet of the contact with the inclosing gneiss, it has been followed with great regularity along the entire exposed outcrop of the dyke. Where a so-called foot-wall has been seen, examination has shown it to be merely the gneiss formation which has been reached in the excavation.

Among other important mines on the east side of the Lièvre may be mentioned the Little Rapids, the Emerald, the Squaw Hill and the Ætna. Others occur such as the Philadelphia, the Salette and the London mines, but the features already stated as to structure apply to all these.

Little Rapids mine.

At the Little Rapids mine on lots 6 and 7, range I., Portland East, along the tramway which leads down from the mine to the river, about one mile distant, pyroxene and granite rocks occur intimately associated with the reddish and gray gneiss which is the country-rock of the district. Just west of the mine itself gray quartzose gneiss strikes N. 20° E. and dips N. 70° W. $<50°$ and this is cut transversely by great masses of pyroxenic diorite. The course of the dyke in which the apatite occurs forms an angle of 30° with the stratification of the associated gneiss, and the dip of the west side of the dyke is east $<80°$. The excavation for the mineral is on the west side of the dyke next the gneiss, the edges of the gneissic strata being exposed on the west side of the cutting, and forms what has been called the foot-wall of the vein. Mica crystals occur along the line of contact of the two series of rocks as well as occasionally disseminated in the phosphate-bearing portion, which may be said to include from four to eight feet of the pyroxene. The eastern wall is a hard grayish quartzose granite which is a secondary dyke cutting the pyroxene, the latter again coming in and being exposed, for a further distance of seventy-five feet, to the inclosing wall of gneiss on the east side. About 250 yards to the south-east of the principal phosphate pit a deposit of mica has been opened in a dyke of pyroxene by Mr. W. A. Allen. This deposit is on the northern extremity of a large dyke of pyroxenite which extends across the range of gneiss hills to the south and which presents a conspicuous feature in this area.

London mine.

On the adjacent lot to the north of the Little Rapids mine, is the London mine, and the contact of the intrusive pyroxene with the gneiss, which is here the banded variety, can be well seen. The dyke in the opening on the face of the cliff fronting the river is nearly on the strike of the gneiss, but the line of contact is sharply defined. The apatite occurs in pockety masses close to the line of contact in the pyroxene.

Photographs of a number of these contacts were made by Mr. H. N. Topley, and have been coloured to show the relations of the different kinds of rock as well as the mode of occurrence of the apatite deposits. These are now on view in the museum of the Geological Survey and form an instructive series of exhibits on this subject.

Ætna mine.

At the Emerald, Squaw Hill and Ætna mines on lots 17, 18 and 19, range XII., Buckingham township, similar conditions are to be seen. At the Ætna, which is the farthest mine to the north-east, located near the summit of a large hill, the gneiss is cut by a broad dyke of pyroxene which here follows nearly on the strike of the gneiss with a course nearly north-east, in which direction it can be traced from the mines at Squaw Hill near the river. The dip of the gneiss and pyroxene is N. W. $<80°$ and the gneiss is much altered along the contact, being broken and very rusty. Several very large crystals of apatite were found in it near the contact with the pyroxene. At this place the pyroxene is cut by another large dyke of diabase near the contact of which, the principal masses of apatite occur. A considerable deposit of iron-pyrites is found along the face of the second dyke.

Squaw Hill mine.

Emerald mine.

At the Squaw Hill mine on lot 18, the rock is a reddish and gray quartzose gneiss. The mine is situated on the east flank of a prominent hill, while the Emerald mine is on the north slope of the same hill. The gneiss is intersected by numerous pyroxene and granite dykes, which have broken up the country-rock and twisted it in all directions, much of it being very rusty near the contact with the intrusions. The apatite deposits here are all in the pyroxene mass, sometimes in great irregular bunches which have produced hundreds of tons. Masses of the mineral are occasionally associated with pink calcite which is an integral portion of the pyroxene rock. In the vicinity, to the east, hills of similar intrusive rock in gneiss are seen, presenting similar conditions to those which prevail at this group of mines, but no attempt has yet been made to develop this area.

Mines north of Perkins Mills.

In the township of Templeton also a belt of pyroxenic apatite-bearing rocks is found, similar to those just described, and in this some of the largest and most productive mines are located. This area lies principally along the east side of McGregor lake and the principal mines here situated comprise the Jackson Rae, Blackburn, McLaurin and Battle lake, with others to the north of Perkins Mills. At all these mines the same association of apatite with the pyroxene, already described, occurs. The latter is clearly intrusive in the reddish and gray gneiss of the district and there are, in addition to the apatite, deposits of mica sometimes of large extent and commercially valuable.

Near the Blackburn mine an anticlinal structure is visible in the gneiss. At the McRae mine on lot 11, range V., Templeton, the strike of the gneiss and quartzite is quite regular and has a course north-and-south, while the pyroxene dyke in which the apatite occurs is almost east-and-west. Granite dykes also occur at these mines but the apatite is always in the pyroxene. McRae mine.

Near the McIntosh mine on lot 4, range VI., a small outcrop of crystalline limestone is seen a short distance south of the workings. The same relations of the apatite to the inclosing rock also occur here. The pyroxene cuts the gneiss and is in turn cut by a dyke of granite. McIntosh mine.

The most northerly group of apatite mines in this district is that in the vicinity of Priest lake and creek, in the townships of Denholm and Bowman. They are situated near the line between these townships and present the same arrangement of rock masses as has already been described for the other areas. The principal areas lie between lakes Scalier and Priest on the south, and the south end of Whitefish on the north. But little work appears to have been done at these places further than development, the position of the mines not being so convenient for the shipment of the mineral as those which lie nearer to the shores of the Lièvre. Priest creek mines.

In none of these mines are workable deposits of the mineral found in the limestone. At several points further west or in the Gatineau belt, the pyroxene frequently contains masses of calcite generally pink in colour, more particularly on the outer or contact zone of the intrusive rock, and these masses are often of large size. In these, very frequently, crystals of apatite are distributed in quantity sufficient to render their extraction profitable especially when, as is often the case, they are associated with crystals of mica as at the Gemmill mine near Cantley, and at others near Wilsons corner. This mingling of apatite and mica is a frequent occurrence in the mines of the Gatineau district throughout the townships of Wakefield and Hull where the principal mica mines are located. It is doubtless this occurrence of apatite in the calcite, which is usually called limestone by the miners, which has led to the statement that workable mines of the mineral are found in the limestone as well as in the pyroxene. The two calcareous deposits should however not be confounded since they are entirely distinct in character. The calcite is invariably a portion of the pyroxene intrusive mass while the crystalline limestone is a true portion of the stratified rocks of the Grenville series ; and in this limestone the apatite, in so far as yet known, has never been found in workable quantities and in fact is rarely seen, except as occasional scattered crystals near to the contact of some pyroxenic intrusion. Association of apatite and mica. Pyroxene and calcite.

Wakefield.

In the areas west of the Gatineau, apatite deposits are rarely found in any economic quantity. Near the village of Wakefield there are several masses of pyroxene, but though a small quantity of the mineral was obtained, it was not sufficiently plentiful to be profitably worked. Near Old Chelsea also small quantities of apatite were found in connection with some of the mica deposits, but the conditions which prevail in the Buckingham district do not seem to occur on the Gatineau. Further west in the township of Ross, apatite deposits have been reported but upon examination the quantity of the mineral was found to be insignificant.

Relations of pyroxene in gneiss and granite.

From the evidence already adduced from the study of these deposits over the entire area in which workable mines exist, it is plain that a very close connection exists between the pyroxene and the apatite and that all the important deposits must be looked for in the former. From the relation also of the pyroxene to the gneiss and limestone wherever these are found in association, it is plain that the former presents many of the features of igneous rocks such as are usually attributed to intrusions of trappean and dioritic dykes, and this leads to the inference that these have had a similar origin. This resemblance is manifested by their cutting the gneisses and other associated rocks at all angles to their strike, by the breaking up and metamorphism of strata in contact, as well as by the formation of crystals of pyroxene, zircon, sphene, mica, &c., and in the presence of various zeolitic minerals. There is also frequently a marked twisting and distortion of the gneissic bands in the immediate vicinity. As for the character of the apatite, crystals are rarely found in the mass of the pyroxene itself, but occur occasionally in the adjacent gneiss or limestone which has been penetrated by the intrusive mass.

In colour the apatite is generally of some shade of green, but reddish and brown tints are also seen, the principal varieties being known as red and green phosphate.

Much has already been written on the subject in previous reports and papers so that further remarks on the commercial aspect of the question, are not considered necessary in this place. The question will be found very fully discussed in the report on the 'Mineral Resources of Quebec.' *

It is to be greatly regretted that all mining of this mineral, both in Quebec and Ontario, has now ceased. The cheapness of the phosphate from the mines in the southern states of America has rendered the

* Annual Report Geol. Surv. Can., vol. IV. (N.S) 1888-89.

mining of it in this country unprofitable, but the existence of great quantities of the mineral in Canada is a well established fact, and the resumption of the industry is only dependent upon a profitable market for the output.

ASBESTUS.

Asbestus. The presence of both asbestus (hornblende) and chrysotile in the crystalline rocks has been known for many years, and attempts have been made from time to time to work these deposits. North of the Ottawa, chrysotile occurs in connection with the serpentinous bands which are apparently a part of the pyroxenite associated with the crystalline limestones, and wherever this serpentine is found traces of chrysotile may be seen. These deposits are generally small. The veins are usually narrow, rarely reaching half an inch in width, and frequently twenty or more small veins of a tenth to a fourth of an inch are seen in a thickness of six to ten inches of serpentine. Occasionally a number of these small veins coalesce and, for a few inches, form a vein of an inch in thickness, but this enlarged vein speedily splits up again into its thin constituents. The short fibre of the Laurentian asbestus is against its successful spinning as compared with the longer output of the Thetford mines. It is, however, very free from the usual impurities, such as grains of iron, usually found in the veins of the latter. The mineral is silky in texture and of a different shade, being usually of a creamy white colour. The areas of the serpentine in the limestone are usually small. They sometimes occur as narrow dykes, and sometimes as masses with a central core of white pyroxenite, and an outer zone of serpentine, as in the Templeton mine, near Perkins Mills, and in the township of Denholm on the Gatineau, near the Paugan falls. In both these places the chrysotile is confined to small veins in the outer zone of the serpentine and not in the limestone which is the country rock at these mines.

Short fibre.

Asbestus localities. The principal localities in which attempts have been made to work this mineral in the Ottawa area are in Portland West, lot 16, range V., on land owned by Nicholas Orange ; and in Templeton township, lot 11, range VIII. At the former place the chrysotile occurs in two principal bands, one of which is near the brow of a ridge of limestone with a band of serpentine near the contact with the gneiss, and with a dyke of white granite or pegmatite along the contact. The elevation of this ridge is about sixty feet above the road at its base, and in the serpentine band there are from twenty-five to thirty small veins in a space of two to three feet. Most of these are mere threads, but some

Nicholas Orange deposit.

reach a thickness of half an inch or even a little more, where, as in Templeton, several coalesce to form for a short distance a thicker vein.

The band of limestone is here exposed for a breadth of about one hundred and fifty yards. A second narrow band of asbestus-bearing rock occurs near the eastern edge of the area, which terminates against a mass of red granite gneiss. In this area the concretionary looking masses of the pyroxenite are not observed.

Templeton deposit.

The Templeton band differs somewhat from that just described. The country-rock is also crystalline limestone, but the serpentinized pyroxenite here frequently assumes the shape of concretionary masses, sometimes like rounded boulders, but also in irregular shaped areas extending downward to a considerable distance. The exposed surface of these masses has often an irregularly oval outline. The masses themselves consist of a core of white pyroxenite, at first sight resembling certain of the limestones but generally slightly harder and finer grained, surrounded by a zone of serpentine, and near the contact with the limestone the small veins of chrysotile occur. In one pit a section is made across one of these pyroxenite masses, which here has the aspect of a dyke showing it to descend through the limestone for at least twenty feet, with a thickness of a little over two feet, along the margin of which the small chrysotile veins are arranged parallel to the walls. Some of the rounder masses of the pyroxenite are detachable from the limestone, and this mode of occurrence presents several interesting features. That the pyroxenite is clearly a distinct rock from the limestone is quite clearly seen at a number of points, and that the chrysotile is confined to the pyroxenite is also manifest. When the limestone is serpentinized the mineral appears in the form of small irregularly distributed spots forming an ophicalcite, but this is distinct from the serpentinized pyroxenite.

Denholm.

The deposit in Denholm near the Gatineau is similar to that in Templeton in the mode of occurrence of the pyroxenite. A sharply defined line can be recognized between these masses and the associated limestone and the small veins of asbestus occur in the same way.

Côte St. Pierre.

Eozoon.

Several other areas of serpentine with small quantities of chrysotile have been found at various points. Thus in the seigneury of La Petite Nation at Côté St. Pierre, about three miles north of St. André Avelin, on the road to Hartwell, a band of limestone occurs between two dykes of greenstone or pyroxenic diorite. The contact between the limestone and the diorite is marked by a zone of serpentine in which small veins of chrysotile are seen as well as an eozoonal struc-

ture. The lower portion of the limestone has small grains of serpentine distributed through it. The locality was at one time worked for asbestus and most of the specimens described under the name of Eozoon Canadense have been obtained at this place.

Sixteen Island lake.

In the township of Wentworth, on lot 20, range IX., south of Silver lake, the belt of crystalline limestone which extends eastward from Lost river to Sixteen Island lake, contains in its lowest part near an intrusive pyroxene, a narrow band of serpentine with several small veins of chrysotile on which an attempt at mining was made some years ago. Some of these veins have a thickness of half an inch. White granite dykes also occur in the immediate vicinity.

Blanche lake.

On Blanche lake also, in the township of Mulgrave, similar serpentine deposits occur with small quantities of this mineral, as also on the east side of Gull lake on the same stream, but it may be said that of all those yet examined in this district the quantity of chrysotile is too small to render its extraction profitable. From the mine at Denholm a considerable amount of the serpentine rock has been shipped.

In this connection in may be remarked that while the small size of the veins prevents their successful separation by the usual process of hand cobbing, a trial of a number of tons through the phosphate mill at Buckingham showed that the smallest veins could be successfully extracted by machinery, the fibre coming from the mill in a clean condition and in good order for shipment.

Pointe au Chêne.

Serpentine also occurs similarly at several points along the Ottawa in the rear of Pointe au Chêne, and a mill was erected at this place several years ago to separate the chrysotile. The amount of fibre was however found to be too small for successful treatment and the works have been closed.

GRAPHITE.

Graphite.

The graphite deposits of the Ottawa district have already been very fully discussed in the 'Report on the Mineral Resources of Quebec,'* but some recent developments in the industry require a brief mention.

Generally speaking all the workable graphite in the district north of the Ottawa is obtained from the grayish gneiss through which the mineral is disseminated in flakes or scales. In places however it occurs in the columnar form in veins of various width and of great purity. The flakes are found both in the gneiss and limestone, but the workable mineral is for the most part confined to the gray gneiss.

*Annual Report, Geol. Surv. Can., vol. IV., (N.S.) 1888-89.

The Walker mine.

This is often rusty, especially where it has been acted upon by intrusive dykes or masses which appear to have developed pyrites in the vicinity of the intrusion. Thus at the Walker mine on lot 19, range VIII., of the township of Buckingham, the rock of the tunnel is a gray gneiss with a band of limestone. Both these rocks carry graphite but the workable portion of the deposit is apparently confined to the former. Along the slope of the hill to the north-east a number of prospecting pits also show the disseminated mineral in this part of the formation in such quantity as to render the property most valuable if properly developed. The limestone at the tunnel is an interstratified bed, and contains numerous inclusions of gray gneiss through the calcareous mass. The strike of the graphite-bearing gneiss is N. 50° E. with a dip to the north-west $< 75°$, but an eighth of a mile north the strike changes to N. 50° W. and the dip is to the north-east $< 80°$. An eighth of a mile east of the mouth of the tunnel the strike of the gneiss is north and the dip east $< 75°$. Vein plumbago is found on the adjoining lot to the south on range VII. A large amount of work has been done on this property in former years and large buildings, fitted with all the necessary machinery for crushing, separating and cleaning for the market, have been erected. The deposit at this place is probably one of the most valuable in the crystalline rocks of Canada.

Pugh and Weart's mine.

On the north side of Donaldson lake, on lot 26, range VI., of Buckingham, another large deposit is located. This is known as Pugh and Weart's mine. It has been worked at intervals for a number of years with apparently indifferent success, and a large sum has been spent in the erection of a crushing and separating plant. The gneiss in which the graphite principally occurs is here also associated with limestone bands and the strike of the strata in the principal cutting is N. 30° W. with a dip to the south-west. The graphite is well disseminated in the gneiss and the percentage in places appears to be quite as high as in much of that at Walker's. Furnaces for roasting the ore, prior to crushing, were erected in 1892, but the process does not appear to be very satisfactory.

McNaughton and Donaldson.

Excellent deposits of graphite are also found on lots 23 and 24 of the same range as the last on the property of Mr. MacNaughton, of Buckingham, and also on that owned by Mr. Donaldson. These were prospected by the late Mr. J. Fraser Torrence some years ago, who reported the mineral quite equal to that at the other mines in the district. No attempt has recently been made to develop these properties.

North American Graphite Co.

Several years ago the North American Graphite Company commenced mining on what is known as the old Dixon area on lot 28, range VI., Buckingham, where a large and valuable deposit of this mineral is found. Mills for the preparation of the graphite for the market were erected, roads made and a considerable quantity shipped. No details as to the working of this place have lately been received. The mineral at this mine also occurs in a gray and sometimes rusty gneiss which is cut by heavy dykes of granite and other intrusive rocks. In fact at all the graphite localities the presence of these intrusive masses is easily recognized.

Area east of Lièvre river.

On the east side of the Lièvre an attempt was made several years ago to develop a deposit of disseminated graphite on lot 13, range X., Buckingham. The locality is near the summit of a high ridge of gray and rusty gneiss along the top of which the mineral is disseminated. The percentage of graphite at this place does not appear to be quite as great as at some of the places west of the river. About 200 tons of the rock with the mineral unseparated were mined and shipped to England, but the transaction appears to have been a failure financially.

Lochaber.

The graphite in the township of Lochaber has already been described in the report for 1888–89, vol. IV., page 135K. An examination of these deposits shows the mineral to occur, for the most part in a rusty quartzose gneiss with which crystalline limestone is interstratified, rather than in the limestone itself. This is the case with the deposits on lot 20, range XII., and on lots 23 and 24, range VIII., as also on lot 24, range VII., which comprise the principal deposits in this district.

Graphite of Grenville.

In the township of Grenville on the south half of lot 10, range V., on a property worked more than fifty years ago, a new company, known as the Keystone Graphite Company, of Wilkesbarre, Penn., has commenced operations. The rocks at this place are largely crystalline limestone, with bands of grayish and rusty gneiss. These are cut by dykes of granite, and diabase, and the graphite is found in irregular veins near the dykes. Various minerals, including scapolite, sphene, pyroxene, apatite, pyrite, &c., are found in the rocks at this place. The results of the mining operations have not been made known, but a large amount of money has been spent in development work. On the lot adjacent to the east, the National Graphite Company, of Scranton, has also commenced mining the graphite, the conditions at both places being somewhat similar.

Lake Terror.

Another deposit which was worked to a limited extent some years ago is situated on the south shore of Lake Terror, on lot 12, range III.,

Portland west. The mineral here occurs as veins of the columnar variety in a hard felspathic rock, but they are not of sufficient size to render their extraction profitable, and work has been abandoned.

IRON.

Iron

But little development in the iron industry has taken place in this area since the publication of the 'Report on the Mineral Resources of Quebec,' in 1888-89.

The principal deposits are those known as the Baldwin and Forsythe mines in the township of Hull, about two miles north-west of Ironsides station, on the Ottawa, Northern and Western railway, (Gatineau Valley) and the Haycock mines in the township of Templeton.

The former occur in somewhat extensive pockety or lense-shaped masses in crystalline limestones, which have been cut by dykes of several kinds of intrusive rocks, and the mass of ore, which is somewhat irregular, has been traced westward over three lots.

Forsyth mine.

Of these mines, that known as the Forsythe is situated on lot 11, range VII., of Hull township, and is the one from which the great bulk of the ore was extracted during the several periods in which these deposits were worked. The ore fills an irregular fissure in the limestone, running in a direction a little north of west. The main cutting in the ore-body extends for about twelve chains west of the road to Old Chelsea. In places, the excavation reached a depth of over one hundred feet, but the ore-body proved to be irregular, being sometimes quite wide but diminishing as the depth increased. At the bottom of the workings, it is said to have a thickness of about eighteen feet.

A large quantity of excellent ore was taken from this mine, much of which was shipped to the United States, but a portion was smelted in a blast furnace at Ironsides village, near the bank of the Gatineau river, the fuel used being charcoal. This old furnace was removed nearly twenty years ago, and no mining has been done at this locality for a long time. The ore contained small quantities of sulphur and phosphorus, but not sufficient to be injurious. There is also a small percentage of disseminated graphite. The ore is largely a magnetite, but sometimes passes into a hæmatite. The extension of the ore-body is not definitely known, but what is presumably its continuation, has been uncovered on the two lots adjacent to the west.

Haycock mine.

The ore of the Haycock mine is also a mixture of magnetite and hæmatite. The quantity visible is not as great as at the Forsythe

mine. Considerable work was done there from twenty-five to thirty years ago, and a small forge was erected, the ruins of which can still be seen. The country-rock at this mine is a mixture of granite-gneiss and diorite, and the ore is irregularly distributed. This property is situated on lot 1, range XI., of Hull, and lot 28, range VI., Templeton. Iron ore is also reported as occurring on lot 2, range X., of Hull, but its value is as yet unknown.

Grenville iron ores.

In the Report of Progress for 1857, Sir William Logan calls attention to a deposit of magnetic iron ore which may possibly be of economic importance. He says: 'It is on the south half of lot 3 range V., of Grenville, the property of Mr. Thomas Loughran. The bed is from six to eight yards in breadth, and it was traced running westward and then turning south-west, the whole distance being about 150 yards. The rock on each side of it appears to be a micaceous gneiss, interstratified with many bands of quartzite. The iron ore and the strata run parallel with one another.' The analysis of the ore by Dr. Hunt gave 52·23 per cent of pure metallic iron.

This bed of ore is said to be cut off by a mass of syenite. Indications of iron ore were also noticed on lot 3 of range IV., and on lot 5 of range VIII., but the quantity observed in these was small.

MICA.

Mica.

The mining of mica in Canada is of comparatively recent date. The mineral is described in the Geology of Canada, 1863 on pages 493 and 795.

The merchantable micas may be included in two divisions, viz., the muscovites and lepidolite varieties or potash micas, and the phlogopite and biotite micas which are magnesian.

Grenville mines.

In the report alluded to, the presence of the mineral in the township of Grenville is mentioned as occurring at several localities. 'One of these is on lot 9, range VI., from which small quantities have been extracted and sent to market. A crystal from this place was so large as to furnish sheets measuring twenty-four by fourteen inches. Good mica has also been found on lot 10, range V., and on lot 1, range X., of Grenville, as well as further to the westward in the Augmentation of that township.'

Usual mode of occurrence.

The recent greatly increased demand for mica, created largely by the manufacture of electrical appliances, has led to renewed search

and to the discovery of new deposits of this mineral, more especially in the townships of Hull, Buckingham, Wakefield, Templeton and Hincks, and considerable energy has been displayed in this direction. In a recent examination of the greater number of the existing mines it was observed that the same peculiar features noticed in the deposits of apatite were common to many of these, and in fact many of the mines once worked for apatite when the market for that mineral was good are now being worked for mica, which in the early days of the phosphate industry was regarded as a waste product of little or no value.

Masses of granite, often in the form of dykes, and of pyroxenic rocks are observed at all the mines. The country-rock is generally a grayish gneiss, though occasionally the deposits occur with crystalline limestone, but in no case was the presence of mica in workable quantity observed without the presence of some form of the igneous rocks.

Villeneuve mine.

One of the earliest known, and at one time regarded as the most important of the mica deposits, was in the township of Villeneuve, on lot 30, range I. The mineral here occurs in a dyke of white granite composed largely of white felspar and quartz, with a breadth of about 150 feet, which cuts nearly along the strike of reddish and gray quartzose gneiss. In this granite dyke a mineralized belt occurs in the first ten feet on the west side near the contact with the gneiss and, in addition to the mica, fine crystals of tourmaline are also found. The felspar of the dyke is of sufficient purity to be valuable in the manufacture of porcelain and considerable quantities were formerly shipped for this purpose. The great drawback in this direction, however, is its distance from the line of railway and the consequent expense of getting it to market. The mica is in crystals, often of large size, of the muscovite variety, and has yielded a large amount of merchantable material. The strike of the gneiss at this point is N. 10° E., the dip west $< 70°$.

Little Rapids mine.

Further south on lot 6, range I., Buckingham, about 250 yards south of the Little Rapids apatite mine a deposit of mica is found in association with a dyke of pyroxene which cuts obliquely across the stratified gneiss. The mica here is phlogopite and is almost entirely confined to the dyke.

Varieties of mica.

Generally speaking it may be said that the mica which occurs in the white granite is of the muscovite variety, while that in association with the pyroxene is phlogopite. The latter is always amber-coloured, and the darker the containing rock the darker is the shade of the mica.

A purple mica is also found in association with some of the smaller dykes of white granite when these cut the crystalline limestone. This is usually a lepidolite, and a biotite mica is also found in association with some of the very dark-coloured diorite the darker shade apparently depending largely upon the greater proportion of iron in the mineral.

Kendall lake.

Mica crystals are found in many of the apatite mines so that certain of these yield both minerals in economic quantities. Crystals of mica are also found in connection with some of the serpentines as at Kendall lake, on lot 26, range XI., Buckingham, the crystals occasionally being of quite large size. Dykes of granite and pyroxene also intersect these rocks and the presence of the mica is apparently due to their action on the strata penetrated.

Similar associations also occur in connection with many of the deposits along the Gatineau in the townships of Hull and Wakefield, the intrusive dykes or masses penetrating both the gneiss and limestone. The details of some of these localities will be given later.

Cameron's mine, Grenville.

The deposits of mica formerly worked in the township of Grenville occur in a similar way. Though an attempt was made several years ago to reopen and ascertain the value of several of these mines, no actual mining has yet been attempted in this place. Of these apparently the most important is Cameron's mine, on lot 7, range II., augmentation of Grenville, where the mica is light-coloured, in crystals of a foot across, some of them a good deal wrinkled, the rocks at the mine being pyroxene with a second dyke of syenite and with a little pink calcite, the country-rock being a grayish quartzose gneiss, with some reddish gray bands. The course of the vein is about N. 23° E. A small quantity of the mineral was also observed on lot 2, range II., some of the crystals being of a dark wine-colour, the containing rocks being crystalline limestone with white granite.

On lot 9, range VI., Grenville, a deposit of mica was opened many years ago and several very fine crystals of muscovite were obtained. The rock is gneiss and limestone cut by dykes of very light-coloured pyroxene and white granite. Not much mineral is now visible at this place as the mine is filled with water but a number of light-coloured crystals were scattered about. The course of the dyke is apparently N. 20° W. the dip to the west $< 80°$. In view of the recent discoveries in the Buckingham district, some of which are very productive, but little attention has been paid to the Grenville district.

Big lake mine Harrington.

Furthur north on lot 8, range IV., Harrington, on the summit of a ridge to the south-west of Big lake, an opening has been made in the gneiss and limestone belt, which is here intersected by a large dyke of pyroxene carrying crystals of dark mica. The pit was sunk only a few feet, the mica obtained being apparently too small and wrinkled to warrant further expenditure. Crystals of mica and a small deposit of graphite also occur with small granite dykes cutting limestone, about two miles east of the road at Lost river but neither is in sufficient quantity to be economically worked.

Whitefish lake mine.

In the township of Bowman, lot 34, range VII., at the south-west end of Whitefish lake, a small deposit of mica has been already referred to. The rocks around this end of the lake are grayish gneiss with limestone bands cut by pegmatite dykes as well as by pyroxene. The mica is found in a large mass of light-coloured pyroxene which cuts the gneiss, and several dykes of the granite cut the pyroxene. The mica crystals are sometimes a foot across the face, but so far most of these are somewhat crushed and of small value. The mica is of the amber variety, and no pink calcite was seen. The crystals occur in fissures through the mass of the dyke rather than at the contact with the gneiss. The presence of numerous dykes, both of pyroxene and granite, in this area should be favourable for the occurrence of mica in workable quantity, but no other deposits were observed around the shores of this lake. The gneiss at the mine strikes about north and south with a dip to the east, and underlies the limestone formation seen on the shores of the lake. Another large dyke of the pyroxene occurs a few yards west of that in which the mine is situated.

Priest creek mine.

About four miles to the south-west of this lake, an opening has been made near the west end of Long lake, in the Priest creek chain. This is said to be on lot 21, range V., Denholm. The mica crystals are dark amber-coloured, occurring in fissures in a dyke of soft grayish-green pyroxene, which cuts reddish and gray gneiss. Some of the crystals seen were of fair size, but the quantity appeared to be small, and the location is so far removed from a shipping point that the expense of handling the output is at present too great for profitable working.

Gatineau district.

Although mica is found at a number of points in association with the apatite deposits of Portland and Buckingham, and is still somewhat extensively mined in this district, the largest workable deposits yet found are apparently nearer the Gatineau river, in the townships of Hull, Wakefield and Templeton, and in consequence of the great importance

at present attached to this mineral, a careful study of the most important localities was made, in order to determine, if possible, some facts relative to its mode of occurrence which might be of practical benefit in the search for it.

Generally speaking, it was found that the mica of commerce in this district occurred under four conditions. In all cases it was associated with intrusive rocks, either pyroxene or some form of granite, often a pegmatite. To some extent it closely follows the arrangement already described for the deposits of apatite, in that it generally occurs near the contact of the intrusion with the inclosing rock, and very often the mica and apatite occur associated in the same mass. This is more noticeable probably where these minerals occur with masses of pink calcite, which forms masses of irregular shape in the pyroxene, and often of large extent.

The different modes of occurrence of the mica may be thus described : Modes of occurrence of mica.

1st. In pyroxene rock near the contact with the inclosing gneiss, which has been traversed by the dyke. Sometimes these dykes follow along the strike of the gneiss, but at others they cut across the stratification at all angles. In this case, very often the pink calcite is found near the contact, and this frequently carries the mica in the form of more or less perfect crystals of all sizes, interspersed with crystals of pyroxene and apatite. Good illustrations of this mode of occurrence are seen at the Gemmill mine in Cantley, on lot 10, range XII., Hull, and at the Burke mine on lot 1, range XII. Contact deposits.

2. In pyroxene rock where the mica occurs in fissures in the mass of the dyke. In this case the crystals are rarely perfect, calcite is usually absent and the mica appears to follow certain lines of fracture or faults, along which it occurs in pockety bunches which are apt to disappear suddenly, leaving the rock apparently barren, till another mass of the crystals is found. Often the crystals are of large size, instances being reported of specimens six to eight feet across the face, but these are frequently crushed or twisted so that there is often a large amount of waste material. A good illustration of this is seen at Wright's mine, near the Cascades, on the west side of the Gatineau, and at the Cassidy mine, east of that river. Fissure deposits.

3. In pyroxene dykes cut by cross dykes of granite or diabase. In this case the mica is generally found near the contact with the second intrusion and the crystals are often of large size. This is well seen at the Powell and Clemow mine (formerly Quinn's), in Hincks, some of the crystals being at least three feet across the face and exceptionally Cross dykes.

smooth though very dark-coloured. A similar mode of occurrence of apatite due apparently to the intersection of the pyroxene by a dyke of diabase is seen at the Ætna mine, on the Lièvre, in Buckingham township already referred to. In most of these cases the pyroxene intersects the gneiss, but at the Hincks mine the country-rock is crystalline limestone.

Pegmatite deposits.

4. The intersection of gneiss by pegmatite granite. These dykes are sometimes several hundred feet across and the intrusion sometimes extends along the strike of the gneiss in which case spurs are frequently given off into the adjacent strata, or it breaks at various angles across the inclosing strata. The mica in this case is muscovite, and it also occurs near the contact of the granite and the gneiss. The mica in the preceding conditions is always phlogopite or when the rock is very dark a biotite. Good illustrations of the muscovite condition are seen at the Villeneuve mine and at the Venosta mine in the township of Low, a short distance north of Venosta station on the Ottawa, Northern and Western railway. This variety of mica is much less abundant throughout the Ottawa district than the phlogopite, but along the lower St. Lawrence the muscovite appears to be the principal variety.

Purple mica.

The purple variety, though not as yet an article of commerce, is usually found in cases where the limestone is intersected by dykes of white granite. An illustration of this is seen in the township of Wakefield, near Lascelles post-office, and also on the east side of the river, about lot 6, range IV., of the same township. There is not sufficient of the mineral for economic mining in either place, but the localities are interesting as mineral occurrences. Another interesting locality for this variety is near Wilsons corner, on lot 11, range XVI., Hull.

Wilsons corner.

By far the greater number of the producing mines yield the variety known as phlogopite, the muscovite variety being apparently confined to the two localities just mentioned. Of the phlogopite or amber mica one of the most important localities is along the east side of the Gatineau river near Wilsons corner, and for several miles to the south and east including the mines at Cantley and Lake Girard. Wilsons corner is situated on the line between the townships of Hull and Wakefield, about six miles east of the Gatineau, and in this area there are numerous masses of pyroxene some of large size, as well as of granite.

On the road west from the corner the first mine noticed is on lot 16, range I., Wakefield. Here the rock is a grayish and reddish-gray gneiss having a strike of N. 20° to 30° west and a dip to the east $<75°$

to 90°. This is cut by a dyke-like mass of pyroxene nearly at right angles to the course of the gneiss. The mica is in the pyroxene and shows a band on the east side of the pit of about two feet in width. A small vein of apatite of eight to ten inches in thickness is associated with the mica, and both minerals occur near the edge of the pyroxene.

Hughes and Haldane.

At Hughes and Haldane mines to the south of this road on lot 12, range I., Wakefield, the mica also occurs in the pyroxene with small bunches of apatite near the contact with red orthoclase gneiss on the south. On the west near the summit of the hill the gneiss strikes north. The principal opening is on the brow of a hill of pyroxene, but several other openings have been made in the vicinity. Occasional secondary dykes of pegmatite cut the pyroxene and with these, or along the contact of the two, small quantities of iron-pyrites are found. At the most southerly opening on the crest of the ridge at this place, the mica is very dark-coloured and is found in the pyroxene near the contact with the reddish-gray gneiss which is seen just on the west edge of the pit. Apparently this peculiarity depends largely upon the colour of the containing rock which is here hard and dark, whereas in the lighter-coloured pyroxene the mica assumes a light shade of amber.

On the north side of the road nearly opposite Hughes' mine is Haldane's old mine. This was formerly worked for phosphate which was mostly red in colour. Small quantities of very dark mica occur here also, and the cutting follows along the irregular contact of the pyroxene and gneiss.

Horse-shoe mine.

Another mine in the vicinity is that known as the Horse-shoe, on lot 14, range XVI., Hull. Here also the country-rock is a reddish-gray gneiss cut by a large dyke-like mass of the pyroxene which is soft and grayish-green. The principal deposit of mica yet worked lies near the contact with the gneiss, on the eastern margin of the dyke in which it is associated with irregular masses of pink calcite and the mica crystals are of good size but sometimes wrinkled or crushed. Crystals of pyroxene also occur in the calcite but no apatite was seen at this place. The strike of the gneiss along the east side of the pit is N. 10° E. the dips S. 80° E. <70°.

Mines north of Wilsons corner.

To the north of Wilsons corner several interesting mines are located which will illustrate certain peculiar occurrences in the mica deposits. Thus on lot 14, range II., Wakefield, pyroxene cuts the eastern edge of a gneiss ridge which extends for several miles north-west along the course of Wilsons creek. At the contact of the gneiss with the north

side of the dyke mass, bunches of pink calcite occur which carry well shaped crystals of mica and apatite. The former are light-amber-coloured, but some of the larger have inclusions of calcite near the centre or sometimes small quantities of apatite in small fissures radiating from a central point which of course seriously affect the market value of the mica. The crystals of mica are found in the calcite but in a portion of the mass of the pyroxene near the contact with the gneiss, apatite was found in the massive condition. The run of the dyke is about north-west and the dip north-east $< 80°$. A short distance to the north-east several openings have been made in the south front of the pyroxene which here intersects the gneiss. Mica and occasionally small bunches of apatite occur in the pyroxene which is apparently much shattered and contains small quantities of pink calcite. Masses of the gneiss appear to be caught in the pyroxene, the contact of the two series being well seen on the north flank of the hill. Most of the observed mica crystals are wrinkled and bunches of pyroxene crystals also occur in the mass. The mineral appears for the most part to be distributed in pockets through the mass of the pyroxene rather than to occur as a contact deposit.

Chubbuck and Wilson mine.

A more important deposit is found half a mile to the north-east of this on the east side of the brook on lot 16, range II., Wakefield. The mica occurs in a gully near the contact of a light-greenish-gray pyroxene. A considerable quantity of pink calcite is found along or near the contact in which the amber mica occurs. Some excellent crystals have been obtained here and small quantities of sea-green crystals of apatite are also found in the calcite. The mining is done by following down on the calcite along the junction of the pyroxene and the gneiss which is sharply defined and this mine is therefore a capital illustration of the contact type.

Seybold's mine.

Not far from this to the south-east are the Seybold mines, on lot 18, range II. On the path up the brook from Wilson's, an opening for apatite has been made, the rock being a pyroxene which crosses the strike of the gneiss and the apatite is of the reddish variety. Scattered crystals of very dark mica also occur in the pyroxene.

The dyke at the Seybold mine is a very dark mottled hornblende rock, in places very hard and containing much iron in its composition. This dyke is broken and jointed and contains patches or vugs of the pink calcite which carries fine crystals of apatite, pyroxene, and mica, while considerable quantities of amorphous apatite also occur. A large mass of hornblende, pyroxene, apatite and calcite, ten feet thick, flanks the north side of the main diorite mass. Portions of this are apparently

composed of felspar and hornblende, the former sometimes purple in colour but generally a bluish-gray. The mica is generally very dark, almost black, in crystals of a foot or more across the face, while great masses of smaller ones are scattered through the calcite near the contact with the diorite.

The north pit on this property also shows small quantities of black mica with some phosphate. The dyke is a very hard dark hornblende and felspathic rock, the mineral contents following a fissure which extends irregularly up the side of the hill. Patches of pink calcite also occur with scattered crystals of apatite, and good crystals of pyroxene also are found at this place. The generally dark colour of the mica is due presumably to its association with a very dark-coloured dyke, and the mineral is impregnated with iron.

Between this point and Wilsons corner several other openings have been made, both for apatite and mica. The conditions seen at all these places are similar to those already described. The pyroxene cuts the gneiss and the mineral contents are, as in the former, near the line of contact.

Lake Girard mine.

The most important mine in this area is that known as the Lake Girard. This is situated on the south side of a lake on lot 24, range II., Wakefield, rather more than three miles east of Wilsons corner. The rocks in the vicinity are mostly reddish-gray and gray gneiss, and several bands of limestone occur about the shores of the lake. About 120 paces back from the shore, on the south side, a large dyke-like mass of pyroxene occurs in which the mine is situated. Several other dykes occur in the vicinity to the south and east, in all of which small quantities of mica were observed. The principal workings were in connection with the large dyke first mentioned, and the excavations have followed downward along or near the contact of the two rock masses to a depth of nearly 250 feet. Large quantities of the pink calcite occur in the pyroxene near the contact, and the mica crystals are for the most part distributed through this. In places these are very abundant and the quality of the output is on the whole excellent, both as regards the size and clearness of the crystals. In some places the calcite is quite barren. A very large quantity of mica has been taken from this mine and hauled to Ottawa, where it is cut for shipment. Only a small part of the large dyke has been extracted, however, and it is quite probable that other portions to the west of the present workings may be equally productive. But very little apatite is found at this mine. A few small crystals are seen at an opening in another dyke about 200 paces east of the principal one. Dykes of pegmatite

also cut the gneiss and limestone at the eastern part of the lake. Work was suspended at this locality for several years owing apparently to depression in the market.

Mines at Wakefield lake

Allan's.

An interesting locality both for mica and apatite is found on the north-west arm of Wakefield lake, on lots 26 and 27, range IV., Portland west. At the apatite mine (Allan's) a number of pits are distributed over the surface of a high ridge of gneiss, cut by pyroxene dykes, which are usually light-green in colour and frequently contain small quantities of iron pyrites. Pinkish calcite is frequently found, through which crystals of red and green apatite are scattered. Quantities of massive apatite also, both green and red, are found throughout the pyroxene. The mica crystals are apparently comparatively few in number and of the amber variety. At several points the pyroxene is cut by dyke-like masses of almost pure felspar, which is sometimes white and at others a pink colour. These felspars should be valuable for the manufacture of pottery, provided the cost of transport is not too heavy.

McRae's mine.

To the south of this on the ridge along the east side of the north arm of the lake, several openings have been made for mica by the McRae Company of Ottawa. That on the north face of the ridge shows the presence of a great mass of the white granite mixed with pyroxene, in which is an irregular vein of pink calcite, through which the mica crystals are scattered. This mass can be traced down the slope of the hill for over a hundred yards. The other or more southerly mine is near the summit of the ridge, near the line between ranges III. and IV. The pink calcite here forms a vein having a course north-and-south with pyroxene, and granite intrusions are also frequent. The mica is dark amber and appears to occur in the pyroxene near the contact with a cross dyke of the granite. A few crystals of apatite also occur in the calcite and the mica crystals are sometimes a foot across the face. No apatite was noted in the opening on the north side of the ridge.

Laurin's mine.

On the road from Deziels corner to Perkins Mills, by way of the north side of McGregor lake, several mines, formerly opened for apatite were examined. In every case the association of mica and apatite crystals was observed in calcite near the contact of the pyroxene and the country gneiss. In Laurin's mine, lot 20, range XII., Templeton, the apatite was in the massive as well as in the crystalline form, the latter being quite abundant in the calcite. The mica in this case was brown.

At the mines of the Templeton and North Ottawa Company, lot 21, range XII., the mica and apatite are intimately associated in the pyroxene which cuts a grayish micaceous gneiss having a strike of N. 45° W. <90°. In neither of these places did the mica appear to be in workable quantity. In fact in nearly all the old phosphate pits around McGregor lake brown or amber mica is found more or less abundantly with the apatite in calcite, but not in paying quantity. McGregor lake.

On the road from Wilsons corner through Cantley, several important deposits of mica were observed. Probably the most extensive of these is what is known as the Gemmill mine on lot 10, range XII., Hull, about half a mile from Cantley post-office. A number of openings have been made along the sides of a knoll of reddish and gray gneiss and granite, which is intersected by several dykes of pyroxene. Most of the mica occurs here as true contact deposits along the gneiss and pyroxene, and the mineral is found almost entirely in the pink calcite. The main veins have a course of north-east with a dip to the south-east. The overhanging wall is sometimes gneiss, the underlying rock being a light-coloured pyroxene. The width of the mica-bearing portion in the principal opening, which is in the calcite, is from three to five feet. The crystals are light-amber coloured, of good size and generally smooth. Another opening to the north of the main pit is near the contact of the pyroxene and a cross dyke of white granite which cuts both the pyroxene and the gneiss, the granite being clearly the later. The crystals here are light-coloured but smaller and somewhat wrinkled. In the most westerly pit near the crest of the hill, the gneiss dips to the north <40°. The pyroxene cuts across the gneiss with a south dip, and carries calcite with mica along the contact. The dyke here runs N. 20° E., dipping S. 70° E. <55°. On the north side of the hill the ridge of banded gneiss dips N. 60° E. <30°. The main dyke in which the principal mica deposits are found has been traced on its north-east course for 1,200 feet. Very considerable quantities of apatite occur in some of the openings at this place along with the calcite. This mine has been photographed by Mr. H. N. Topley, and the relations of the different rocks and minerals can be clearly seen. Gemmill mine.

The Webster Company's mine is situated on lot 10, range XII., Hull. A number of pits have been sunk on a knoll of gneiss which is intersected by pyroxene and diorite dykes. Some of the latter are hard and hornblendic. Pink calcite occurs near the contact of the dyke with the gneiss, and the mica and apatite occur mostly in the Webster mine.

calcite though the latter is also found in the massive pyroxene. Several of these dykes are highly felspathic. The gneiss dips S.E. $<60°$.

Mines south of Wilsons corner.

To the south-west of Wilsons corner several interesting mica mines have been worked. Of these the Wilson, Chubbuck and McLelland are the principal. The latter is on lot 12, range XVI., Hull, and is interesting from the presence of serpentine in association with which the mica occurs. The pyroxene cuts the limestone formation at this place and the serpentinizing of the rock may be due to this fact. To the south-east of this opening a cut has been made in a brownish felspathic dyke which also crosses the limestone. The mica crystals seen are small, rarely more than three inches across and of a dark-brown colour. A similar occurrence of mica in a dyke, cutting limestone, is seen on lot 7, range IV., Wakefield, the mica having the same purplish-brown colour.

Wilson mine.

At Wilson mine on lot 13, range XVI., Hull, pyroxene cuts the reddish gneiss. There is here a very considerable development of the pink calcite and a large quantity of apatite, the latter occurring both in the calcite and the pyroxene. The mica is light amber, the crystals sometimes a foot across the face. The dip of the gneiss at the contact is E. $<55°$ and the dyke cuts the gneiss transversely to the strike.

Chubbuck mine.

A short distance to the west of this on lot 12, range XV., an opening in pyroxene shows, on the south side of the dyke, a very considerable deposit of mica and apatite crystals which underlies the limestone on the north. The strike of the dyke is N. 40° W. and the dip is to the south-west $<50°$. The pink calcite is well exposed along the contact and contains most of the crystals which are often of good size, though the property had been but slightly opened up. Red and gray gneiss lie to the north of the dyke. To the north of this another opening on Chubbuck's property shows great ledges of pyroxene cutting the gneiss and the mica and pyroxene crystals occur in fissures in the dyke itself. At another opening to the west, on lot 13, range XVI., Hull, one of these fissures carries calcite and some very large crystals of smooth mica were obtained. The excavation was carried down to twenty-five feet and hugh crystals of pyroxene occur here which are well terminated. The associated gneiss is generally reddish or reddish-gray in colour and the pyroxene is light-grayish-green and soft. These are not contact deposits but appear to resemble segregations along lines of fissure through pyroxene itself. In the pit which produced the largest crystals of mica and pyroxene no apatite was seen,

while in most of the other pits adjacent, it occurs in considerable quantity. In several other openings on the adjoining lot to the south of those just described, similar conditions are seen. The pyroxene cuts the gneiss, sometimes transversely to the strike, at others nearly with it, and mica and apatite occur, though none of these mines are at present being operated.

On the back road, east of Cantley, on lot 3, range XIII., Hull, a pyroxene dyke cuts reddish and gray gneiss and is in turn cut by a dyke of hard felspathic rock. Apatite and mica occur here along with a little pink calcite in the pyroxene near the contact with the cross dyke, which would therefore appear to have had some effect in producing the mineral deposit. A quarter of a mile further north a similar occurrence is seen. The pyroxene here has apparently burst through the gneiss but not reached the surface as there is a capping of the gneiss along one side of the pit overlying the pyroxene. A diorite dyke also cuts the pyroxene, and along the contact iron-pyrites, calcite and mica are scattered; the crystals occur along jointings in the pyroxene and are generally much twisted.

Burke mine.

Another interesting location in this vicinity is at the Burke mine on lot 1, range XIII., Hull. Here a large dyke of pyroxene cuts the gneiss, portions of the latter being seen along the north side of the pit. This place was formerly worked for apatite and yielded a large amount of this mineral as well as large quantities of amber mica which occurred along with the apatite and which was thrown into the dump as useless. These crystals as well as the apatite were distributed through that portion of the pyroxene near the gneiss along with pink calcite, the relations of the several minerals to the containing rocks being well seen. Huge crystals of pyroxene are seen at this place one on the south side of the pit being over a foot in diameter. This mine has also been photographed by Mr. H. N. Topley, for the Geological Survey.

On the road south from Cantley to Wrights Bridge, a succession of gneissic and granite rocks are traversed for several miles. The relations of the pyroxenic and granitic rocks to the stratified gneiss are well exposed at a number of places. Attempts have been made to mine mica on lot 7, range X., Hull, but the crystals are small and generally dark-coloured.

Nellie and Blanche mine.

One of the largest mines worked for mica in this district is the Nellie and Blanche, on lot 9, range X., Hull. This deposit is for the most part in a great mass of pyroxene through which the mica is distributed apparently along lines of fissure and the deposits are therefore not true

contacts like those at the Gemmill mine. Some of the openings here have reached a depth of almost 200 feet, the pink calcite is rarely seen at this place but apatite is occasionally found in small quantity.

The above mines comprise most of those on the east side of the Gatineau in the townships of Hull and Wakefield. Several deposits are found, however, in Templeton in the vicinity of Perkins Mills which will be referred to further on.

Brown, Fleury, Fortin and Gravelle.

On the west side of the Gatineau river deposits of the mineral are found at a number of places at no great distance from the river. The most southerly in this direction are Brown's mine, on the south end of lot 19, range VII., Fortin and Gravelle, on lot 18, and Fleury mine, on lot 20, Hull. Here a band of reddish and gray gneiss separates two broad belts of crystalline limestone and is cut by soft light-green pyroxene, the mica occuring in pink calcite near the contact with the gneiss. The pyroxene here has a dip of S. 40° E.

Scott mine.

To the north of Old Chelsea a short distance west of the road leading to Kirks Ferry, the Scott mine is situated on lot 14 and 15, range IX. At the south opening the country-rock is a reddish and gray gneiss of the usual type which is cut by small irregular dykes of pyroxene carrying small quantities of red apatite and dark amber mica. The gneiss has a dip to the south-east, and the limestone in the valley adjacent dips to the east. In the main pit a fourth of a mile to the north-east the gneiss is well banded and cut by dykes of various kinds such as pyroxene, granite and diorites. These are generally small, cutting at times along the course of the gneiss. Some ten to twelve tons of mica crystals were taken from this place, all amber-coloured and some of good quality. Red apatite also occurs here and a small quantity of bright red jasper is found in one of the dykes. Further to the north-east another opening has been made in pyroxene associated with the crystalline limestone but the mica here is unimportant.

In the hills a fourth of a mile north of Old Chelsea corner, numerous pyroxene masses are found with the gneiss. At one place on Chamberlain's lot a great mass of pyroxene crystals is seen with bunches of red apatite and small crystals of amber mica. East of the Kirks Ferry road in rear of the church, similar occurrences of mica in small quantity are noticed but the crystals yet found are too small to have much economic value.

On lot 15, range X., similar pyroxenes in gneiss, carrying mica, were also noted, as also on lot 17, and several openings have been made. In one of these the pyroxene shows green phosphate in calcite with

small mica crystals. Going west the intrusive mass is a hard black, dioritic-looking rock, and the mica contained is correspondingly dark-coloured as is also the case in a third pit where the country rock is gray and red gneiss having a strike N. 10° W. with a dip west < 50° The mica here is also dark and in small crystals.

Kirks Ferry Haycock mine.

Approaching Kirks Ferry on lot 17, range X., several openings have been made by Mr. Haycock, of Ottawa, which present some points of interest. On the west side of the road and about 100 yards from it the gneiss strikes N. 20° W. and dips N. 70° east < 40° to 60°. This is cut by a dyke of pyroxene having a course east and west with a breadth of about four feet. At the west end of the cutting the dyke is capped by the gneiss. The upper part of this dyke for five or six feet carried apatite, but below this the mica came in and yielded some very fine crystals of the amber variety. The dyke is vertical. Further on another cutting in pyroxene with red gneiss shows bunches of pink calcite near the contact, in which are the usual crystals of mica and pyroxene. Cross dykes of white granite cut the pyroxene at this place.

On the east of the post-road near the Gatineau on lot 12, range XI., two dykes, one of pyroxene and the other of granite, cut the gneiss. The former forms the foot wall of a mica deposit, the granite the upper, and the crystals are formed along the contact between the two. The gneiss at this place and also at that first mentioned has a synclinal structure, the intervening space being occupied by limestone.

Connor's mine.

Going north, on lot 14, range XI., stratified gray and red gneiss dips east and is cut by small dykes of pyroxene from one to three feet wide. At one point two small dykes of pyroxene come together and in the cavity near their intersection many small crystals of apatite occur, mostly red in colour. These dykes are too small to be worked successfully, but 100 yards further north on the slope of the hill, a larger dyke has been opened from which a number of fine crystals from ten to fifteen inches across, were obtained. Many of these are, however, too much crushed to be of economic value. A considerable quantity of apatite was also mined at this place but no pink calcite was noticed.

Cascades mines Wright's.

Just above the Cascades on the Gatineau and a fourth of a mile back from the river, on lot 23, range XV., is Moore's or Wright's mine. The hill here is apparently largely composed of pyroxene or diorite, and the openings, which are numerous, are apparently situated along lines of fissures in this rock. They extend over the crest of the hill, and though but little pink calcite is seen at any of them, masses

of mica crystals are numerous. Most of these are imperfect or irregularly formed, and all are of the amber variety. Small quantities of apatite are seen at some of the openings. Some very large mica crystals were obtained at this place, but most of these were too much crushed to be of much value. This mine presents none of the features of the contact deposits, but is like the Nellie and Blanche.

Cross mine.

To the west of the Cascades mines, on lot 24, range XIV., Hull, on the property of Mr. Cross, a mass of pyroxene with heavy dark hornblende rock cuts the gneiss. The mica crystals in the dark rock are very dark-coloured also, but in the lighter portions are of much lighter shade. At this place there is a very large outcrop of intrusive rocks of various kinds, and it is probable that these continue across to the mine at the Cascades, which is less than a mile to the north-east.

Cassidy's mine.

On the east side of the Gatineau, on lots 15 and 16, range XV., Hull, two interesting mines are located. Of these, the most southerly is Cassidy's, and is like that at the Cascades, in that it is situated in a heavy mass of pyroxene which cuts red and gray gneiss. The pyroxene is greenish-gray with portions mottled with white, and the mica deposit extends across the pyroxene in a fissure and is from one to two feet thick with a course of N. 40° W. A second and smaller vein cuts across the south-east end of the pit. This deposit is entirely in the pyroxene, and there is no pink calcite showing. Cross-dykes of white granite cut the pyroxene. There is no gneiss within fifty yards of the mine. The crystals of mica are amber coloured and of large size, often twenty inches across the face and some reaching a breadth of nearly three feet, but most of these are imperfect. Green apatite occurs in the south-east end of the principal opening. Half a mile to the north of this is Macfarlane's mine, the path in the interval crossing a band of crystalline limestone which overlies the gneiss to the north of Cassidy's. Macfarlane's openings are for the most part along the contact between the pyroxene and the gray gneiss, with the usual deposit of pink calcite, which carries crystals both of mica and apatite. Some of the former are from eight to ten inches across the face, light-coloured and smooth. In the other pits a short distance to the north, the calcite is in very small quantity and the mica much crumpled. Several other openings have been made in a very hard diorite rock, in which small quantities of iron-pyrites are found, but the mica in these is dark and the crystals unimportant, being small and much twisted.

Macfarlane's mine.

Further north, in the townships bordering along the Gatineau, deposits of mica are found at widely separated points. Thus in the township of Low, lot 36, range XIII., a band of reddish and gray

gneiss separates crystalline limestone and is cut by a heavy dyke of grayish granite near the north-east end of a knoll. The mica crystals (muscovite) are found in the mass of the granite. They were of good size and smooth, but few in number. The strike of the gneiss here is N. 40° E., the dip S.E. <70°. This is what is known as the Venosta mine. The pit is only a few feet deep, work having ceased on the disappearance of the mineral some years ago. Venosta mine.

Further north in Hincks, lot 22, range II., a very large surface show of mica crystals was seen. Three openings were made in pyroxene, cutting limestone. The dyke is of a large size and is cut by another of white granite, the mica occurring in proximity to the cross dyke. This mica is dark-coloured but remarkable for the size and smoothness of many of the crystals some of which were more than three feet across the face. The mine was opened in 1893, and about 200 tons of crystals taken out. The strike of the country-rock, mostly crystalline limestone, in the vicinity of the mine is about N. 25° E. and masses of white granite are seen at a number of places. This mine was worked by Clemow and Powell. Hincks, Clemow and Powell mine.

On the bank of the Gatineau a short distance below Aylwin, several openings were made in a granite dyke also cutting limestone but the crystals were mostly too small to be commercially valuable.

Further north in the township of Wright, on lots 14 and 15, range D, on the north side of the Gatineau, several deposits of mica occur. That on lot 14 has been opened up and extensively worked for some years. The country-rock is a gray gneiss, well stratified and cut by a dyke of greenish-gray pyroxene which holds bunches of pink calcite. The sides of the opening which was originally about eight feet wide and twenty to thirty feet deep, are studded with mica crystals ranging in size up to a foot across the face. The number of these is very great, but many of the largest are injured by the presence of small cracks across the centre in which inclusions of calcite or apatite occur. A large quantity, of mica has been taken from this place. Large dykes of white granite are also numerous in the vicinity. The deposit on lot 14 adjacent is near the crystalline limestone, and dykes of pyroxene and granite are also common. A similar occurrence of mica crystals is also seen here but the locality has been but slightly tested. St. Antoine or Guay mine.

South of the Gatineau on the west side of Bittobee lake, small deposits of mica crystals are found in connection with pyroxene and granite, which cut both the gneiss and limestone, but the quantity does not appear to be very extensive. Further north in the township Bouchette.

of Bouchette, on lot 31, range I., another mica mine is located in a mass of pyroxene cutting a gray and sometimes rusty gneiss. The crystals here are mostly distributed through the dyke and are very dark-coloured and often twisted. But little gneiss is visible in the vicinity of the mine.

Several other deposits have been noted in this area but the quantity observed is generally small. It may, however, be stated that where dykes of pyroxene cut the gneiss or when these are cut by the white granite the chances for mica are much better than when these rocks cut the limestone, judging from the localities yet examined.

Mines near Perkins Mills.

It will be seen therefore from the descriptions given of these deposits that certain portions of the townships of Hull and Wakefield contain by far the greater number of workable deposits of this mineral in the Ottawa district, at least in so far as our researches have extended in this direction. As regards the deposits in Buckingham, Templeton and Portland, while the presence of the mineral has already been pointed out in connection with the apatite deposits at the Blackburn, McLaurin, Jackson, Rae and several other mines in the vicinity, comparatively little attention was paid to the presence of the mica for some years, though the crystals were often abundant and of good quality. Several valuable mines however are situated in the vicinity of Perkins Mills, which have been extensively worked, among which may be mentioned lot 16, range VIII., Templeton (Wallingfords), in which the output is also of the amber variety.

In the area included in the map-sheet No. 122, with the exception of the mines already noted in the vicinity of the Gatineau, deposits of this mineral are very rare or at least have not yet been located. The rocks are somewhat different in character over much of the area and there is an absence of the great development of pyroxenic rock so conspicuous in the Lièvre and Gatineau districts.

In the above descriptions of the apatite and mica deposits of the Ottawa district, it may be stated that the greater part of the examinations were made by this department several years ago. Much development work has been carried on in this area since that time and a number of new areas have been located, some of which have been quite extensively worked. A number of the old mines formerly worked for apatite, in which mica was found and at that time regarded as a waste product, have been operated as mica mines for several years and have proved among the most productive in the district. The details of these new workings were not known at the time of our examinations, but as

the information regarding these deposits is of interest to the mining community, and in order to render this portion of the report as complete as possible, additional details have been obtained from the reports of Mr. J. Obalski, mining engineer for the province of Quebec, and are here added.

In the township of Templeton, in addition to the localities already described, the occurrence of mica may be mentioned as follows :—

On lot 21, range IV., indications on the property of Mr. McTierney.

On lot 22, range IV., Taylor and McVeity, an old apatite mine, reopened for mica in 1898, from which a considerable quantity has been extracted.

Lot 20, range V., W. Smith, indications.

Lot 10, range VII., Stevenson mine, worked by several parties at different times, and in 1899, by Mr. J. Asquith, of Ottawa. A large quantity of good mica is reported as taken from this mine from a large surface trench. Distance from East Templeton, 10 miles.

Lot 14, range VII., prospected by the American Mica Co., Boston. No returns available.

East half lot 15, same range, formerly worked, 1891, by Hon. C. A. Dugas, and in 1896–97 by Baumgarten and Manchester, has yielded a considerable quantity of good mica. In the latter year worked by the Webster Co. to a depth of fifty feet. Ten miles from East Templeton.

West half of lot 15. Worked by several parties since 1893. Quite extensive operations in 1897–99, to a depth of 70 feet, and is reported to have yielded a large quantity of excellent mica associated with apatite, some of the mica crystals being of large size.

Lot 16, same range, Wallingford mine, worked regularly since 1892. One of the largest and most productive mines in the district, the output of merchantable mica being very large. The crystals often of large size and excellent quality. The mica occurs in a large dyke of pyroxene, cutting the grayish gneiss, and has been worked to a depth of over 170 feet along an excavation 200 feet in length. The mine is well equipped with machinery for the extraction of the mica. Apatite is also found in large quantities at this place. Mica is also found on the south half of lot 17, same range, twelve miles distant from Templeton station on the Canadian Pacific railway.

Lot 4, range IX. Worked at intervals since 1892, and has yielded a large amount of good merchantable mica. Known as the Sophia mine. Twelve miles from Templeton station.

South half lot 11, range IX. Prospected in 1894, by the North Templeton and Ottawa Mining Co.

Lot 13. Indications of mica.

Lot 14. Worked for apatite twenty years ago, and since 1894 for mica. The mineral occurs with pink calcite in pyroxene and a considerable quantity of mica has been extracted with the apatite. It has recently (1899) been worked by Jurkowsky and Co.

Lots 16–21, also prospected by the same company, no returns.

Lot 7, range X. Prospected in 1900 by McLaurin & McLaren. No returns.

Lot 8, same range. The Marsolais mine, formerly worked for apatite but since 1897 has been worked irregularly for mica, of which a considerable quantity has been extracted. Fourteen miles from Templeton.

East half lot 9. Post mine, Canada Industrial Co., formerly a phosphate mine, has recently yielded a quantity of mica, some of the crystals being of large size.

West half lot 9. Jackson Rae mine, formerly worked for apatite, has since 1892 yielded a considerable quantity of mica.

North half lot 10. Jubilee mine, formerly worked for apatite, also contains mica in considerable quantity.

East half lot 10. Also formerly worked for apatite, contains a small quantity of mica, worked by Mr. A. Murphy.

West half lot 15. Has yielded several tons of apatite and mica in close association.

Lot 16. Victoria mine, opened in 1899, by McLaurin and McLaren. Excavated for 300 feet in length by 60 feet in depth, and has produced a large quantity of excellent mica as well as of apatite.

North half lots 7, 8, 9, 10, 11. The Blackburn mine, formerly worked for apatite, of which it was a large producer, the mica then being regarded as a waste product. Worked at intervals since 1891 for mica, and has produced a large quantity of excellent mineral of large size. It is one of the most important mines in the Templeton district.

Indications of mica are also found on lots 12, 13, 14, 24 and 27, range XII., and on lots 3, 4, 5, 13 and 17, range XIII. Good sized mica, but somewhat broken, is also found on lot 38 of the Gore.

In the township of Hull work has been carried on in recent years by the Brown Bros., of Cantley, on the following lots :—

Lots 19, 20, 22, range VI., and on lots south half 18, the Eva mine, as also on south half 19, the Aberdeen mine. There is a large quantity of mica in several of these pits, much of it of excellent quality and good size. This is hauled to Cantley and there dressed for the market.

North half lot 18, range VII., the Fortin and Gravel mine, opened 1899 in pyroxene, has yielded a large quantity of good mica, some of which is of large size. It has been worked to a reported depth of 90 feet in one place.

South half lot 20, range VII. The Fleury mine, opened in 1900, shows large dyke of pyroxene carrying excellent mica, one crystal of superior quality measuring 24 by 28 inches. The deposit has not been largely developed.

All the above locations are a short distance south of Kingsmere.

The Scott mine on lot 14, range IX., and the Cascades mine on lot 22, range XV., have already been described.

Lot 23, range XV., Ferguson mine, opened in 1899 by Mr. H. Flynn, is with calcite in pyroxene, and has yielded a considerable quantity of medium-sized and small mica.

The Moore mine on lot 24, range XV., and the Gorman mine on lot 27, range XVI., have been but little worked. The latter was opened in 1898 by Mr. Bishop, of the Cascades.

These are all situated to the west of the Gatineau river.

In Hull township, east of the Gatineau, the following may be noted :—

Lot 7, range X., the Foley mine (Big Crystal mine) had a fair showing of mica, from which it is reported twenty-five tons were taken, but work has apparently ceased since 1898.

Lot 5 and south half lot 6, range XI., the Kearney mine, worked in 1892, by Messrs. Rae and Allan, has yielded considerable mica. The Eureka mine, on lot 6, same range, was also worked in 1893 by Mr. Perkins, and about eight tons were extracted.

North half lot 10, range XI., Nellie and Blanche mine, has already been described. It was at one time one of the largest producers in the Gatineau district, but no work has been done here for several years.

Lot 10, range XII., the Gemmill or Nellis mine, already referred to, and has been a steady producer for about ten years.

South half lot 1, range XIII., the Burke mine, formerly worked as an apatite mine, was opened in 1894 for mica, which had formerly been regarded as a waste product. It has yielded a considerable quantity of good mica, some of the crystals being of large size. Already referred to.

North half lot 12, range XV., the Dacey mine, worked in 1898-99 by Webster & Co. Mine excavated to a depth of about 50 feet, and has produced a quantity of generally small sized mica.

South half lot 13, same range, originally worked as an apatite mine, was opened in 1898 by Clemow and Powell for mica, the mineral occurring with calcite in pyroxene. Produced some good mica, but not of large size.

North half lot 13. James Connors, worked by Webster & Co. in 1892, and in 1899 by the owner. Small quantity only reported.

East half lot 15, same range. Jameson mine, worked for several years to a reported depth of 75 feet, and has yielded some mica of large size.

In the township of Wakefield the principal mica mines have already been referred to. They lie to the north and east of Wilsons corner. Work has, however, been carried on within the last four years at several of these, more particularly at those known as the Comet mine, south half lot 15, range II., in 1898-99; at the Kodak mine, lot 16, same range, which was worked to a reported depth of 110 feet along a distance of 200 feet, yielding a large quantity of good mica, and more recently in 1900 by Jurkowsky & Co., and in 1900 by Webster & Co. The mica occurs in pyroxene with a heavy band of pink calcite.

East half lot 17, range II., the Morris mine opened in 1892 has produced several tons of large mica some crystals measuring 12 by 24 inches.

The lake Girard mine on lot 33, range II., has already been referred to and has been for years a very large producer of excellent mica. It is well equipped with modern mining machinery. The works for the last three years have been under a new management.

In Portland west, on Lake Terror, is the Lake Terror mine from which several tons of good amber mica were obtained several years ago. This is on lots 12 and 13, range III. On lot 15, same range, a mine opened in 1900 has produced a small quantity of good mica and on the north-half lot 24 the Lila Mining Co., of Ottawa, employed a number of men in 1899 on a property formerly worked for apatite and extracted several tons of good sized crystals.

On lots 26, 27, 28, range IV., the old apatite mines of Fleming and Allan were opened in 1891 for mica, and for several years produced a large quantity of that mineral. The old apatite mine on lots 5 and 6, range IX., formerly the McIntosh mine, has also been a producer of mica to a considerable extent. Work was carried on at this place in 1899-1900.

In Portland east, on east half lot 1, range I., the Judge mine, opened first in 1893, was reopened in 1900, results unknown, and on the west half lots 1 and 2 same range the Glen Almond Mica and Mining Co. has done a large amount of surface working from which a considerable quantity of generally small sized mica has been obtained. This company has also operated on lot 23, range II., Derry, but no returns of this development are to hand. Work has also been done on lots 3, 4 and 6, range III. This place was formerly worked for apatite.

On lot 9, range I., Derry, Mr. W. A. Allan in 1900 opened a mine. Operations chiefly confined to the surface workings, and several tons were extracted.

In Buckingham, on north half lot 25, range IV., some work was done in 1899 by Mr. Tétreau, and in 1900 by Mr. D. Richard. Several tons of generally small mica were obtained.

In the township of Hincks, in addition to the mines of Clemow and Powell already described, some exploratory work was done in 1897–98 on lots 3–6, range IV., generally small mica was found in pyroxene with calcite, and in several areas near lake St. Mary also, but the mica of this district in so far as yet developed is usually of small size and in limited quantity.

In the township of Northfield, on lot 1, range A, a mine was opened in 1895, and subsequently worked in 1896-98, by the Toronto Mica Manufacturing Co. Several excavations reaching a depth of 30 feet were made, the mica occurring with calcite in pyroxene. The mica obtained was usually of small size though some good crystals were found, and work here has ceased. Some work was also done on lot 2 adjoining, and on lot 8, from which a small quantity of mica was obtained.

On lot 19, range B, a mine was opened in 1898, by Syneck and others. Several openings were made and some tons of somewhat imperfect mica were obtained. The exact results have not come to hand.

In Wright township on lot 6, range A, a mine was opened in 1898 by Mr. Watters. The pyroxene here contains some pink calcite but the rock is generally hard and dark coloured and the mica is also dark. The excavations reached a depth of 15 to 20 feet. The mica is for the most part of small size, though a considerable quantity was obtained. Work was carried on at this place in 1900 by Webster & Co.

At the St. Antoine mine on lot 15, range D, a large amount of work has been done in recent years, the mine being the most productive in the Gatineau district. The mica occurs in crystals sometimes of large size and in great abundance in a pinkish or gray calcite in a large dyke of pyroxene cutting a grayish gneiss. In 1900 the depth of the excavation was over 90 feet and for several years the daily output of rough mica was about three tons. It has recently been worked by the Sills Co., of Chicago. The mine is near the north bank of the Gatineau, about seven miles east of Gracefield.

On lot 12, range V., near the road one mile south of the Pickanock river is the Moore mine. It is in a knoll of pyroxene, and has been opened only by surface workings. The output so far has been generally of small size though crystals of large size are also reported. It was worked at intervals in 1898-99.

The above descriptions, taken in large part from the recent reports of Mr. Obalski, embrace most of the locations in which mica has been worked or known to occur in economic quantity. Indications of the mineral are, however, found at many other points, some of which may yet develop into productive mines, but owing to lack of development nothing can now be said as to their actual value. In an area so traversed by masses and dykes of pyroxenic rocks and granites, mica deposits will undoubtedly continue to be found at many other points throughout the district north of the Ottawa, since over a large portion of the area between the Gatineau and Lièvre rivers and in the country adjacent to these streams the conditions are highly favourable to the occurrence of both mica and apatite.

BARITE.

Barite in Foley mine.

Only two deposits of this mineral are known in the area north of the Ottawa. One of these, formerly the Foley mine, is on lot 7, range

X., township of Hull, near the road to Cantley, and occurs in connection with the granite dyke which cuts the crystalline limestone. The mineral is in small irregular veins along the course of the dyke, ranging from one to two feet in width, and associated with masses of purple fluor. This deposit has within the last two years been worked to some extent by a Montreal paint company and a quantity of the barite has been shipped to that place. Another similar deposit is seen along the back road towards the Templeton line, on lot 3, range XI., of Hull, but has not yet been developed to any extent. The actual value is therefore unknown.

FELSPAR.

Felspar.

Some of the pegmatite dykes are largely made up of felspar, either white or red in colour, and in some of these the mineral is sufficiently pure to be economically available for the manufacture of certain kinds of porcelain or pottery. The presence of iron in the rock is highly injurious, but the red colouring of the felspar disappears in the process of manufacture, and the resulting silica is snow white.

There are large masses of this rock throughout the area occupied by the crystalline rocks, but much of it is too remote from convenient shipment to be economically valuable. The pegmatite dykes are numerous in the areas of crystalline limestone though they cut the gneiss formation also.

Papineauville.

Large areas are seen near the village of Papineauville where the mass is nearly white, but these are said to contain too great a proportion of quartz and small quantities of mica, which is also injurious, and prevents these deposits from being utilized. A large quantity was at one time shipped from the great dyke at the Villeneuve mine, the quality of the felspar being excellent, but in this case the distance from the Lièvre river and the subsequent transfers from boat to rail rendered the handling unprofitable. The freight rate to the United States where the felspar was shipped, and the low price obtainable, combined to render the industry almost unprofitable. Several quarries were operated a few years ago, one of which was near Templeton station, about twenty tons a day having been shipped for several months, but the work is now suspended.

Villeneuve mine.

Kaolin of Amherst.

The Kaolin deposit in the township of Amherst has not yet been developed though the quality is said to be excellent. This could now be shipped by the railway from St. Jérôme into Arundel. The extent of the deposit is, however, unknown.

BUILDING STONES.

Building stones.

The limestones of the Chazy, Black River and Trenton formations have long been noted for the excellence of their material for building purposes, and large and valuable quarries exist in the areas occupied by these rocks. Among these may be mentioned the Ross quarry, in the township of East Hawkesbury, in limestones of Chazy age, and from which a very large amount of excellent stone was taken for construction work on the Grenville and Carillon canals. Near L'Orignal also quarries are found in the Black River and Trenton formations, (Murrays) the stone from which has been used for the same purpose. Butler's quarry in the Chazy limestone about three miles west of L'Orignal near the river road, and several others in the Black River or Trenton limestones in adjoining lots are well known and the quality of stone is excellent. These are in the western part of the township of Longueuil.

Ross quarry.

L'Orignal quarries.

Quarry in Potsdam sandstone.

Further west on the north side of the Ottawa, between Papineauville and Montebello, a quarry is located in the Potsdam sandstone which has yielded a large amount of stone. To the south of Rockland the large quarry of Mr. A. Stewart, from which much of the stone for the Soulanges canal was obtained, is situated in a bold escarpment of Black River and Trenton limestone, the latter forming the upper portion of the cliff. The great quarries of Hull near Ottawa are also in the Trenton limestone.

Lachute.

Quarries in the crystalline limestone are rarely seen in the area north of the Ottawa. The rock is occasionally used for lime-burning, and there is a quarry opposite the village of Lachute from which a large amount of good stone has been taken. On the east spur of Rigaud mountain also there is a quarry in the granite from which large blocks for monumental work have been obtained.

Some of the crystalline limestones of the Grenville series are dolomitic and in certain bands should be sufficiently magnesian to be suited for the manufacture of wood pulp by the chemical process. No efforts to utilize these have as yet been made.

OCHRES.

Ochres of Grenville.

On the eastern part of lot 17, range VII., township of Grenville, a hill of serpentine is seen along the east side of a ridge in which a mica mine, already referred to, is located. In this rock are pockety masses

of a brown ochre which has been worked in former years by a Montreal company for paint, but nothing has been done in connection with this locality for some time. The serpentine rock is in places a beautiful stone, but the rock is apparently too much shattered to furnish blocks for decorative purposes, except of small size.

PEAT.

Peat. Along the south side of the Ottawa, deposits of peat are numerous and extensive. Most of these are beyond the limits of the map-sheet. In the Geology of Canada, 1863, several areas are mentioned where peat occurs, some of the deposits being of sufficient size to be economically important.

Deposits n Grenville. On the north side of the Ottawa, in the township of Grenville, three of these peat bogs have been observed. One of these on lots 4 and 5, of range V., covers about thirty-six acres, and has a depth of ten feet. It has been used in the neighbourhood and is pronounced of excellent quality. Another deposit of about the same extent occurs on lot 1, of the same range and is in parts more than fifteen feet in thickness. A third of about thirty acres occurs on lot 4, of range VII. A fourth deposit was seen in a tamarack swamp extending over about forty acres of lots 4 and 5 of range I., of Harrington. All these areas should be easily drained. The depth of the Harrington deposit is from ten to twenty-five feet.

PEAT AND MARL.

Shell marl Argenteuil. In Argenteuil, on lot 3, range I., an ancient lake basin is filled with peat, the extent of the deposit being about twenty-two acres. The peat has a thickness of nine feet and is underlain by shell marl ranging in depth from five feet to thirteen feet. On the same lot is another peat bog with a length of half a mile from east to west and a breadth of one hundred to one hundred and fifty yards, also underlain by marl with a reported depth of twelve feet.

Wentworth Marl is found in Eagle Nest lake, on lot 28 of range VIII., of Wentworth; and also in a pond on the lot 5 of range IV., of Harrington. Along the lower Ottawa in the seigneury of Vaudreuil at Pointe à Cavagnol is a bed of marl extending over twenty acres, with a thickness of from twelve to eighteen inches.

Low. Deposits of marl are also found in several of the lakes along the Gatineau river. No examination of these has been made, but one was noticed a short distance west of the road along the river in the bottom of a lake in the township of Low.

Rensselaerite. Rensselaerite, a hydrous silicate of magnesia, is found on lot 13 of range V., of Grenville. It seems to cross into the same numbered lot on range VI., and appears to be in considerable quantity. It is also found at Old Chelsea village, on the road near the forks to Kingsmere and on the property of Mr. Chamberlain, at this place.

GRANITES.

Granite quarry of Grenville. In connection with the granite masses of Grenville, large quarries have been opened quite recently for building stone. One of the most important of these is on lot 14 and east half of lot 15, range VII., Grenville, owned by Mr. Joseph Brunet, under the name of the Maritime Granite Company, Montreal. The rock breaks readily into large angular blocks suitable for building purposes, is coarsely crystalline, reddish in colour, and is used in Montreal both for building and paving stone. The deposit is extensive, on the south slope of a steep ridge, and is hauled to St. Philippe station on the Canadian Pacific railway for shipment.

APPENDIX

LISTS OF FOSSILS OBTAINED FROM THE SEVERAL FORMATIONS ALONG THE OTTAWA RIVER PERTAINING TO THE REPORT ON SHEET No. 121, QUEBEC AND ONTARIO (GRENVILLE SHEET).

By HENRY M. AMI, M.A., D.Sc., F.R.S.

POTSDAM SANDSTONE.

From quarry in Potsdam sandstone, between Papineauville and Montebello, Ottawa river.

Protichnites lineatus, Owen, or a closely allied form.
Protichnites septem-notatus, Owen.

CALCIFEROUS.

From Lachute, Quebec. Collected by H. M. Ami and Mr. W. McOuat, 1890.

Ophileta complanata, Vanuxem.
Pleurotomaria Canadensis, Billings.
Murchisonia Anna, Billings.

From point near Carillon, Que. Collected by Mr. George Wanless.

Lituites Apollo, Billings.

CHAZY.

From Chazy beds, north of Stewart's quarry, near Rockland. Collected by H. M. Ami, 1893.

Orthis imperator, Billings.
Orthis borealis, Billings.
Orthis platys, Billings.
Rhynchonella (*Camarotœchia*) *plena*, Hall.
Pleurotomaria (*Raphistoma*) *stamineum*, Conrad.
Modiolopsis parviuscula, Billings.
Orthoceras Antenor ? Billings.

From Grenville, collected by G. J. Hinde, 1879.

Prioniodus radicans, Hinde, 1879.

From Butler's quarry, three miles west of L'Orignal. Collected by L. M. Lambe, 1891.

Rhynchonella (*Camarotœchia*) *plena*, Hall.
Pleurotomaria (*Raphistoma*) *docens*, Billings.
Illaenus, sp.

From same locality, collected by W. E. Deeks, 1891.

Malocystites Murchisoni, Billings.
Leptœna fasciata, Hall.
Pleurotomaria (*Raphistoma*) *docens*, Billings.
Orthoceras, sp.
Bathyurus, sp.
Leperditia Canadensis, Jones.
Ostracoda, other species.

From road between L'Orignal and Murray's quarry.

Orthis (*Hebertella*) *imperator*, Billings.
" *borealis*, Billings.
" sp., very minute.
Rhynchonella (*Camarotœchia*) *plena*, Hall.
? Helicotoma, sp.

From Ross's quarry, Little Rideau, six miles east of Hawkesbury. Collected by L. M. Lambe, 1891.

Glyptocystites, sp.
Malocystites Murchisoni, Billings.
Palœocystites tenuiradiatus, Hall.
Bolboporites Americanus, Billings.
Orthis (*Hebertella*) *borealis*, Billings.
Orthis " *imperator*, Billings.
Rhynchonella (Camarotœchia) plena, Hall.
Asaphus canalis, Conrad.

From same quarry. Collected by W. E. Deeks, 1891.

Cryptozoon, sp.
Bolboporites Americanus, Billings.
Palœocystites tenuiradiatus, Hall.
? Coscinium proavium, Eichwald.

Stictopora, sp.
Ptilodictya, sp.
Branching monticuliporoidea.
Orthis (*Hebertella*) *borealis*, Billings.
" " *imperator*, Billings.
" " *perveta*, Conrad.
" *platys*, Billings.
Rhynchonella (*Camarotœchia*) *plena*, Hall.
" sp.
Zygospira, sp, nov.
Atrypa acutirostra (=*Zygospira acutirostra*, Hall, sp).
Pleurotomaria calyx, Billings.
? Trochonema umbilicatum, Hall.
Hyolithes, sp.
Asaphus canalis ? Conrad.
Asaphus, sp. indt.
Bathyurus, cf. *B. Angelini*, Billings.
Harpes, sp.
Leperditia Canadensis, Jones.

BLACK RIVER LIMESTONE.

Stewart's quarry, near Rockland, lower portion. H. M. Ami, and Archibald Stewart, Esq.

Columnaria Halli, Nicholson.
Tetradium fibratum, Safford.

TRENTON LIMESTONE.

Stewart's quarry, near Rockland, Ont. Collected by H. M. Ami

Crinoidal fragments.
Streptelasma corniculum, Hall.
Prasopora Selwyni, Nicholson.
? Homotrypa similis, Foord.
Stictopora (*Pachydictya*) *acuta*, Hall.
Rafinesquina alternata (Conrad) Emmons.
Orthis (*Dalmanella*) *testudinaria*, Dalman.
" *tricenaria*, Conrad.
Ctenodonta, sp. indt., cf. *C. abrupta*, Billings.
Serpulites dissolutus, Billings.
Orthoceras, sp.

Asaphus platycephalus, Stokes.
Endoceras proteiforme, Hall.
Calymene senaria, Conrad.

From Murray's quarry, near L'Orignal, Ont. Collected by W. E. Deeks and R. Hugh Ells, 1891.

Crinoidal fragments.
Prasopora Selwyni, Nicholson.
? Diplotrypa Whiteavesii, Nicholson.
Branching forms of Monticuliporoidea.
Trematis terminalis, *Emmons.*
Strophomena incurvata, Shepard (=*Streptorhynchus filitextum*, (Hall.)
Plectambonites sericea, Sowerby.
Rafinesquina alternata (Conrad) Emmons.
Platystrophia lynx, Eichwald.
Rhynchotrema inæquivalvis (Castelnau).
Conularia Trentonensis, Hall.
Calymene senaria, Conrad.
Asaphus megistos, Locke.
" *platycephalus*, Stokes.
Dalmanites callicephalus, Green.
Ostracoda. Several species.

From same locality. Collected by L. M. Lambe, 1891

Pachydictya acuta, Hall.
Rafinesquina alternata (Conrad) Emmons.
Trematis terminalis, Emmons.
Strophomena, resembling *S. Philomela*, Billings.
Orthis (*Dalmanella*) *testudinaria*, Dalman.
Platystrophia biforata, var. *lynx*, Eichwald.
Rhynchotrema inæquivalvis (Castelnau).
Parastrophia hemiplicata, Hall.
Trochonema umbilicatum, Hall.
Cyrtodonta, sp.
Endoceras proteiforme, Hall.
Dalmanites callicephalus, Green.
Lichas Trentonensis, Conrad.
Ceraurus pleurexanthemus, Green.

From Foxes Creek, Clarence township, Ont. Collected by R W Ells, 1893.

Crinoidal fragments.
Pachydictya acuta Hall

Prasopora Selwyni, Nicholson.
? Monotrypella Trentonensis, Nicholson
Discina, or *Trematis*, sp.
Crania, sp.
Lingula quadrata, Eichwald.
Plectambonites sericea, Sowerby.
Strophomena (Rafinesquina) alternata, Conrad (Emmons).
Strophomena incurvata, Shepard.
Orthis (Dalmanella) testudinaria, Dalman.
" (*Dinorthis*) *pectinella*, Conrad.
" (*?*) n. sp.
" or *Anazyga* or *Zygospira*, sp.
Platystrophia biforata, *Schlotheim*, var. *lynx*. Eichwald.
Rhynchotrema inæquivalvis (Castelnau.)
Bellerophon sulcatinus, Emmons.
Calymene senaria, Conrad.
Ceraurus pleurexanthemus, Green.
Illaenus sp., cf., *I. Trentonensis*, Billings.
Asaphus platycephalus, Stokes.
" *megistos*, Locke.
Dalmanites callicephalus, Green.
Trinucleus concentricus, Eaton.

Ridge south of Cumberland village. Collected by Dr. F. Slater Jackson, 1890.

Streptelasma corniculum, Hall, or an allied form.
Crinoidal fragments.
Plectambonites sericea, Sowerby.
Rafinesquina alternata (Conrad) Emmons.
Strophomena fluctuosa, Billings.
" cf. *S. tenuistriata*, Sowerby.
Platystrophia biforata, var. *lynx*, Eichwald.
Rhynchotrema inequivalvis (Castelnau).
Zygospira recurvirostra, Hall.
Liospira Progne, Billings.
Trochonema umbilicatum, Hall.
Hormotoma gracilis (Hall).
? Omospira Alexandra (Billings).
Asaphus, sp., apparently *A. platycephalus*, Stokes.
Calymene senaria, Conrad.
? Lichas, sp., cf. *L. Trentonensis*, Hall.

GEOLOGICAL SURVEY OF CANADA
ROBERT BELL, M.D., D.Sc., LL.D., F.R.S.

REPORT

ON THE

SURFACE GEOLOGY

SHOWN ON THE

FREDERICTON AND ANDOVER QUARTER-SHEET MAPS

NEW BRUNSWICK.

BY

R. CHALMERS.

OTTAWA
PRINTED BY S. E. DAWSON, PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1902

No. 769.

To Robert Bell, D.Sc., M.D., LL.D., F.R.S.,

Acting Director of the Geological Survey of Canada.

Sir,—I beg to submit herewith a report on the surface geology of the Fredericton and Andover quarter-sheet maps (No. 1 N.W. and No. 2 S.W.) of the New Brunswick series.

My best thanks are due to Principal Harrison of the University of New Brunswick, Fredericton, for barometric readings taken at the Meteorological station under his charge.

I have the honour to be, sir,
Your obedient servant,

R. CHALMERS.

Geological Survey Office,
Ottawa, May, 1901.

NOTE.—*The bearings in this report are all referred to the true meridian and the elevations to mean sea level.*

REPORT

ON THE

SURFACE GEOLOGY

OF THE

FREDERICTON AND ANDOVER QUARTER-SHEET MAPS,

NEW BRUNSWICK.

BY

R. CHALMERS.

INTRODUCTION.

Former investigations in the area.

The investigation of the surface geology of the western part of New Brunswick was begun in 1882-83 and a report relating to it published in 1884, but without maps to accompany it.* The systematic mapping of the surface deposits in the area of the Fredericton and Andover sheets (Nos. 1 N.W. and 2 S.W.) was commenced in 1892-94, but was discontinued till 1898-99 when it was completed. The two sheets referred to being now printed, it is proposed to publish them accompanied by a short report on the surface geology, economic minerals, forest growth, etc., which shall be, for the most part, supplementary to the one issued in 1884.

Character of the investigations.

In carrying out this investigation every accessible part of the area included in the two map-sheets mentioned was traversed and a careful examination of the surface deposits made. The character of the soils, whether these were formed by the disintegration and waste of the underlying rocks or consisted of boulder-clay, or of the later modified deposits, was carefully investigated. The distribution and peculiar characters of the different species of trees growing in the region were also ascertained and noted. On the east side of the St. John river new settlements have been opened up in the area of the Andover sheet since the explorations and surveys of 1882-84 were made, and a number of roads had to be sur-

* Report of Progress, Geol. Surv., Can., 1882-83-84, Part GG.

veyed in addition to those on the map. A considerable body of new data has been obtained in the area, which will be detailed in the following pages.

My assistants in the field were Mr. W. J. Wilson for a short time in 1898 and 1899, and Mr. L. P. Silver, of Kingston, Ont., for four months of the latter season.

PHYSIOGRAPHY.

The region embraced in the two $\frac{1}{4}$-sheet maps under examination may be characterized as undulating with a gradually ascending surface from the Carboniferous plain north-westward to the South-west Miramichi and the Upper Tobique waters, or the interior highlands of New Brunswick. Three principal topographical divisions may be observed within the region, each with distinct physical features of its own. These may be briefly described as follows:—First, the Middle Carboniferous or sandstone area which is for the most part, level and underlain with rocks in a nearly horizontal attitude. In the valleys of the St. John and Oromocto rivers this area is not more than from 50 to 100 feet above the level of the sea, but it rises gently towards the north-west margin where it attains a height of 600 to 800 feet. Second, a narrow belt of Lower Carboniferous rocks, which comes up from beneath the north-west margin of the gray sandstones. Generally speaking these rocks are higher than the gray sandstones. Eruptive masses protrude in them forming ridges and hills from 500 to 1,000 feet in height above the sea. McLeod and Clarke mountains east of the St. John and Bald mountain, Harvey hill and others west of this river are the most conspicuous, and are intrusive in or near these Carboniferous belts. Along the south-east margin of the gray sandstones described, another band of Lower Carboniferous occurs in which several ridges and hills were also noted. The surface of the country occupied by the last mentioned formation is generally uneven and broken, but the soil is usually fertile. The areas of Lower Carboniferous rocks in the Beccaguimic and Tobique valleys exhibit surface features which are less diversified than those in the localities just described, but at the northern limits of the latter the Blue mountains rise upwards of 1,720 feet above the sea—a prominent mass of eruptive rocks.

Topographical features and divisions.

Lower Carboniferous outliers.

The third area which presents a different topography and has a different elevation from those above referred to, is that occupied by rocks mapped by the Geological Survey as Silurian and Cambro-Silurian

which underlie a large portion of the country within the western and north-western limits of the two map-sheets. The general surface of this area may also be characterized as rolling, though sometimes rising into ridges and mountains. The average height, in and near the St. John valley and west of it, is from 400 to 500 feet, but towards the north and north-east it is from 800 to 1,000 feet or more. The most noteworthy of the higher elevations are Hainsville ridge, Howland ridge, Pole hill, Golden ridge, Kincardine and Birch ridges east of the St. John and Magundy and Blaney ridges, Dorrington hill, Carroll and Pocowogamis ridges and Oak mountain on the west. The soils over a large part of this area are good. Elevations.

Traversing this area in a north-east and south-west direction are wide belts of granite and pre-Cambrian rocks which usually have a greater elevation than the formations on either side. Hills and ridges, lake basins, boulder-strewn moraines, and a coarse stony soil are the prevailing characteristics of these granite areas. The country through which they extend is mostly in a forest-clad, wilderness condition and unfit for settlement. The northern part of the region embraced in the two map-sheets is largely occupied by these granite and pre-Cambrian rocks and rises into a rugged broken plateau from 1,000 to 1,500 feet high or more, the elevation of which increases northward beyond the limits of the Andover sheet. No well defined range of mountains exists in this part of the province, but denuded remnants of that spur or lateral extension of the Appalachian system cross it in the north-western part and are to be seen in Mars Hill just west of the International boundary, 1,688 feet above sea level according to the Boundary Survey, and Moose Mountain east of the St. John 1,490 feet in height, with other hills about the source of Munquart river and to the east. At and beyond the northern limits of the Andover sheet (No 2 S.W.) we reach the south-westerly extension of the interior highlands of the province which trend from here away to the north-east in an irregular range or series of elevations to the headwaters of the Tête-à-gauche and Jacquet rivers, attaining altitudes in some parts of 2,500 to 2,700 feet above the sea. Granite belts. Character and elevation of central highlands of New Brunswick.

The northern part of the Andover sheet covers an area which is still under forest and to a large extent a *terra incognita*. The South-west Miramichi river and its tributaries drain the north-eastern part, while the Tobique drains the north-western. The country here is, generally speaking, broken and elevated, with an average height of 800 to 1,000 feet above the sea, but a number of hills and ridges reach an elevation of 1,200 to 1,500 feet. Mr. Wilson, who examined the

South-west Miramichi valley along some of the lnmbermen's portage routes, says: 'The north branch of the South-west Miramichi flows through a broken, wilderness country, with high hills bordering its banks. The average elevation of the country about the head waters of Burnt Hill and Clearwater brooks is from 800 to 1000 feet, with hills rising 200 or 300 feet higher, and the height along the portage road from Pleasant Ridge settlement to the Dungarvon is 800 to 900 feet. Along the main river the banks arc comparatively low in many places, but there are numerous high peaks which stand out conspicuously above the surrounding land, such as Louis, Otterslide and Todds mountains. At the junction of the north and south branches the elevation is about 800 feet, where the portage road from Green hill crosses it about 700 feet, and at Boiestown 195 feet.' A large part of the area drained by the South-west Miramichi and the Upper Tobique is unfit for settlement. Beaufort and Golden Ridge, which were at one time supposed to be thriving settlements, have of late been nearly deserted.

RIVERS AND LAKES.

Rivers in the area mapped.

The principal rivers of this part of the province are the St. John, which traverses it from north to south, through Victoria and Carleton counties, and from north-west to south-east in York and Sunbury; the South-west Miramichi, from its source to Ludlow, Northumberland county; the Tobique, from the junction of the Wapskehegan; and the lower part of the Aroostook. The smaller tributaries of the St. John on the north and east are the Nashwaak, Keswick, Nacawicac, Beccaguimic, Shiktehawk and Muniac; on the south and west there are the Oromocto, Pokiok, Eel, Meduxnakeag, Presquille and Des Chutes. In the area of the Fredericton sheet (No. 1 N.W.) the rivers flowing from the southern watershed into the Bay of Fundy or Passamaquoddy bay are the Magaguadavic and St. Croix. The St. John is the great artery, and extends throughout the whole length of the province. It is probably one of the oldest drainage channels of eastern North America, having trenched a deep, wide valley with sloping banks through rocks of different geological ages and different degrees of hardness down to the base level of erosion.

St. John river.

Interesting features of the St. John.

The St. John exhibits some very remarkable features in the lower part of its course. These appeared to be so interesting that some special study was made of them, and a brief description of the tidal phenomena of this river will therefore be given here. As is well known, the tides of the Bay of Fundy affect it as far up as Springhill,

about ninety miles from its mouth, and enter Belleisle bay, Washadamoak, Grand and Maquapit lakes. The rise and fall of these tides were approximately ascertained in the summer of 1897 by Prof. A. Wilmer Duff.* At Indiantown, above the falls at the mouth of the river, the actual range of the tides was found to be 16 inches, and at Springhill 5·2 inches. The height of spring tides in St. John harbour above low water mark is 27 feet and of neap tides 22 feet. Prof. Duff's tables are independent of any datum related to the tides of the Bay of Fundy, however, so that the height and attitude of the tidal waters in the St. John river have no reference to mean sea level or to the tidal survey bench-mark at St. John harbour. Moreover, the tidal range in the river will probably be found to differ in different seasons, and at the same season in different years, as it depends on variable conditions, such as the quantity of fresh water in the river at the time, or the tidal range in St. John harbour or the Bay of Fundy. Until the St. John river is levelled from the mouth to Fredericton or Springhill with reference to mean tide or the bench-mark mentioned, our observations must be regarded as merely approximate.

Bay of Fundy and St. John river tides.

Prof. Duff's Tables.

The discharge of the waters of the St. John over the falls at the mouth is considerably greater than the inflow, notwithstanding, that the barrier is approximately at half tide level. The peculiarity of these falls is that at ebb tides there is a flow from the river over the barrier into the harbour, while at high water the tides from the harbour flow over it up river. The following information in reference to the time and duration of the flow and ebb is given with the Tide Tables for St. John harbour: 'The falls are level, or it is still water at about three hours and a half on the flood, and about two and a half on the ebb. Much depends on the floods in the St. John river and the time of high water or full sea, which is often hastened by high southerly winds.' Between every two high tides therefore the flow over the falls outwards lasts on an average fully seven hours, while the inflow lasts only about five hours. At neap tides the inflow is less, the time being shorter than at spring tides, and the outflow is correspondingly greater. It is during the low autumn level of the river that the tidal fluctuations are most marked, the inflow then being at its maximum as compared with the outflow. Occasionally at the time of spring and fall floods in the St. John river, on the contrary, the inflow is scarcely perceptible, or is not observed above Gagetown, fifty miles up river. Instances are, indeed, known when the river floods reach such a height as to check or swallow up the tidal inflow

Falls at the mouth of the St. John.

Tidal fluctuations in the St. John estuary.

*Bulletin Nat. Hist. Soc. of N. B., No. XV., 1897, pp. 65-82.

altogether. The river then pours out a current through the gorge at the falls incessantly during the twenty-four hours until its waters subside.

Non-tidal oscillations of the St. John river.

But there are other conditions which have to be taken into account in regard to the tidal waters of the St. John and one of these is the oscillation of the non-tidal portion above Springhill. In the year 1898 the writer in determining altitudes in the counties of York and Sunbury above the river level observed some facts which made it doubtful whether high tides in the St. John river were at the same level as the same high tide in St. John harbour. To test this question was a difficult matter, owing to the want of levels or bench-marks along the river. At certain points however the Canadian Pacific railway was found to approach it, and on levelling from the stations at high tides, the following data were obtained which may be regarded as at least approximately correct, showing the height of the river as compared with that of the same tide at high water in St. John harbour:—At Westfield Beach, eighteen miles up river, or fourteen by rail, high tide on October 14, 1898, was found to be 6·60 feet lower than in the harbour mentioned. At the railway bridge, Fredericton, it was 1·77 feet lower than its initial tide at the same harbour. Levellings at Fairville between the Canadian Pacific railway station and high tide in the St. John river; also at Rothesay between the Intercolonial railway and the Kennebeckasis, show the tidal waters at these places to be lower than the same high tides in St. John harbour. The figures are, however, subject to correction, being based only on railway levels.

Levellings at certain points along the river.

The facts regarding the seasonal fluctuations of the St. John from the falls at the mouth to Springhill show that except for a few miles above Indiantown, perhaps as far as the Long Reach, the general rise and fall of the river are dependent, not on the tidal flow, but on the rise and fall of the non-tidal part above Springhill, that is, upon the meteorological conditions which affect alike the rivers and lakes of the province. When the non-tidal part rises the tidal part rises, and when it subsides so also does the latter. The few inches of tidal waters which flow and ebb have but little effect on its general fluctuations. Further, the above data go to show that the waters of the St. John tidal basin between the mouth of the river and Springhill are not level, but have a gentle inclination even at their lowest stages in autumn from tide head towards the Bay of Fundy. Owing to the fact that the outflow is so much greater than the inflow, there is a lowering of the waters during the summer months to a level, for the most part, below that of high tides in the St. John harbour, as shown

Inclination of the river in the tidal portion.

by the measurements at Fredericton, Westfield Beach and Fairville, recorded on a former page, and this is never more than partially compensated by the inflowing tides.

The waters of the great basin of the lower part of this river, of which Grand and Washadamoak lakes are about the centre, seem to be in a state of continual oscillation. Generally speaking, their level ranges between the high tide and mean tide levels of the Bay of Fundy throughout the greater part of the year. In the spring and fall seasons, however, the volume of water poured into this basin from the flooded rivers above is so much greater than can escape through the narrow gorge at the mouth that there is a general rise of the waters throughout its whole extent, occasionally reaching such a height that it overflows the spring tides seeking ingress over the falls at the mouth. During the low summer and autumn level of the St. John, when the waters of the lower part of the basin are, at ebb tides, nearly at mean sea level, the flood tides from the harbour rush in through the narrow gorge at the falls with great rapidity, partially filling the basin for some distance up river, but how far has not been ascertained. Before the basin can be filled, however, the ebb tides set in. At the maximum and before the tide turns, a hydrographic depression would seem to be produced at some point above Indiantown, probably at Grand Bay. Beyond this point the inflowing tides have to move up river on a slightly ascending surface, and must be largely of the nature of an undulation or series of undulations.

Average level of the St. John estuary.

Hydrographic depression.

How long, geologically speaking, have the existing estuarine conditions of the St. John prevailed? To answer this question we have to go back to the beginning of the Recent period. At that time the land would seem to have stood slightly above its present level and one or more drift dams near the mouth held in its waters above the tidal flow. In that part of the St. John valley which is now tidal, a great lake then existed and occupied the basins of Grand and Washadamoak lakes and the Kennebeckasis valley, to which reference is made in a previous report.* Terraces and shore-lines were observed in a great number of places at heights of 80 to 100 feet above the sea. For this body of water I propose the name Lake Acadia. Complete details regarding its limits are still lacking, and I await an opportunity of obtaining these in order to map this lake. Its waters seem to have been fresh until the barrier at the mouth of the St. John was eroded and the land underwent a slight subsidence. Then the sea invaded the lower part of the river valley and the existing tidal oscillations commenced.

When the tides of the Bay of Fundy first entered the St. John estuary.

Lake Acadia.

* Annual Report, Geol. Surv. Can., Vol. IV., (N.S.) 1888-89, pp. 57-58 N.

The South-west Miramichi.

The South-west Miramichi is also an old river, but only the upper part lies within the area of the Andover sheet. A remarkable feature of this river is that it now partially drains a district the waters of which were once very probably tributary to the St. John, that is to say, the upper part of this river, above the junction of the north and south branches may have been drained into the St. John by the Nashwaak or its tributary the Napudogan. The wide granite area at the county line between Carleton and York was at that time probably the watershed between the St. John and Miramichi waters here. Crustal movements and the denudation of this granite area seem to have afterwards diverted the waters of these branches, originally forming part of the Nashwaak, into the South-west Miramichi.

Beccaguimi river.

The north branch of the Beccaguimic river has a singularly tortuous course, the origin of which is difficult to explain, unless we suppose that a part of its waters at one time flowed along the present valley in a reverse direction to what they do now, and thence into the Nacawicac river. Another hypothesis, however, is that the area now occupied by Carboniferous rocks here was, for some time, a basin or sink into which several streams discharged, forming a lake, and subsequently on the upheaval of the district the existing drainage lines were inaugurated.

The Tobique river.

The Tobique river likewise exhibits some peculiar physical features. A large outlier of Lower Carboniferous rocks also exists in the valley of this river, the lower border of which is only seven or eight miles from the St. John river. These rocks like those of Beccaguimic have originally been laid down in a basin, and as the land rose and denudation proceeded the river had to re-cut its channel through them, and great wear and waste of the soft sandstone sediments seem to have taken place.

In the Pleistocene period the valley of the Tobique was partially filled with boulder-clay near the mouth, which formed a barrier, and on the retreat of the ice a large lake appears to have been held in the valley above this barrier extending as far up as the Gulquac, or perhaps, to the Blue mountains. After a time the waters of this lake cut a new passage or outlet through solid rock, now called 'The Narrows,' where the river still flows in a series of rapids, and has not yet reached the base level of erosion.

The Tobique "Narrows,"

A number of peculiar and noteworthy features were observed in other rivers, but it is impossible to present them all in detail. Only two or three more of the tributaries of the St. John will be briefly referred to, and these seem to have had their valleys and probably the drainage which finds outlet by them changed by crustal move-

ments in the later geological periods. The Pokiok is one of these. This river flows from Lake George north-westward into the St. John, in a reverse course to that of the latter, along a channel very little above the general level of the surface, and appears to be of late origin. At its mouth there is a beautiful series of cascades in a narrow gorge cut in granite. It may be that the drainage which now finds discharge by this river has been partially diverted, originally flowing into the Magaguadavic or Oromocto. If this is the case, then the Pokiok river originated as a result of a differential uplift of the belt of rocks extending north-east and south-west at Harvey station, Canadian Pacific railway, which consist largely of intrusives. The flat district to the north-west of this belt, in the southern part of which the two Cranberry lakes lie, seems formerly to have had its entire drainage carried into Magaguadavic and Oromocto rivers. At the present day a part of it is carried to the St. John by the Pokiok river.

The Pokiok river.

The Keswick and Nacawicac rivers occupy wide valleys, containing great quantities of stratified gravel, terraced in some places, but often thrown into irregular kame-like forms. These two valleys are joined by another wide valley, or rather the whole constitutes one valley from the mouth of the Nacawicac round by Burtt lake and Upper Keswick, thence to the mouth of the Keswick. Just east of Burtt lake is the highest point, which is 538 feet above sea level. This part of the valley is also heavily drift-encumbered, and resembles a deserted river valley. Viewing this valley as a whole, it is difficult to conceive of the existing rivers and brooks having eroded it and transported and deposited such large quantities of gravel and sand as are now found there; and the conclusion seems, therefore, unavoidable that the rivers must at one time have had a larger volume of water than at present. One hypothesis is that the Nacawicac ran across by Burtt lake, joining the Keswick river and forming part of it. An alternative one is that the St. John may have flowed through this valley for a time. This would imply different relative levels from those which now exist, of which there is but little evidence, though it would appear that the great rectangular block of land bounded by the valley described above and the St. John river may have sustained a differential uplift and became tilted towards the south-east.

The Keswick and Nacawicac.

The portion of the region south of the St. John river contains a large number of lakes. Many of these are drift-dammed, but a few seem to be bodies of water ponded by unequal or differential changes of level in the land. Of the latter class are the Cranberry lakes and

Cranberry and Oromocto lakes.

Oromocto and probably others. Oromocto lake occupies a singular and apparently abnormal position. It is situated very nearly in the south-west corner of the great Carboniferous area of New Brunswick, its elevation being by aneroid 415 feet above mean sea level. Two miles west of this lake the Magaguadavic river flows along a valley, its bed only 270 feet above sea level, a ridge 550 feet in height intervening. The south-western rim of the Carboniferous rocks has probably sustained a differential uplift here relatively to that to the east. The lake seems to be rock-rimmed, overflowing its basin to the east.

The Cranberry lakes and Lake George are very nearly on the same level, the former being 486* feet above the mean tide level of the Bay of Fundy. These lakes lie in hollows in a plain, the width of which extends from the Harvey hills to Blaney ridge. Big Cranberry has evidently drained eastwards by the gap in the hills just mentioned through which the Canadian Pacific railway runs until quite recently, the old channel which its outlet followed being distinctly seen along the upper part of Lyon stream, which flows into Oromocto river.

Magaguadavic lakes.

Magaguadavic and Little Magaguadavic lakes are bodies of water ponded in an old pre-glacial valley which were dammed by boulder-clay in the glacial period and had since to re-cut a channel for themselves. They are both on the same level, namely, 377 feet above mean tide of the Bay of Fundy.

The Cheputnecticook group.

The Cheputnecticook group of lakes originated from a similar damming by drift at the head of the Ste. Croix river. First and Second lakes and Palfrey are at the same level and are 377 feet above mean tide at St. John. Grand and North lakes, also held in by a drift barrier are about 50 feet higher, or 427 feet above the sea. A number of headlands extend diagonally into these lakes, from the New Brunswick side with deep inlets between, more especially in the First and Second Cheputnecticook. Great quantities of drift occur around their margins and apparently beneath them, and many islands dot their surface. The peculiar conformation of the drift deposits along the New Brunswick border of these lakes is due to the fact that the original basin extends in approximately a north-east and south-west direction, while the ice of the glacial period, which produced the morainic accumulations referred to flowed very nearly due south.

Eel River lakes.

The Eel River lakes are drained northward into the St. John and lie in a north-and-south depression, parallel to that of the Cheputnecticook group. The height of First Eel lake by aneroid is about 520 feet above the sea, and of the second about 550 feet.

*The elevations of the lakes near the Canadian Pacific railway are based on the profile heights, of that line.

Skiff, Bolton Sheogomoc lakes, etc.

About fifty other lakes, large and small, spangle the surface of the granite and adjacent rock-formations of western New Brunswick in York county, as shown on the map, the largest of them being Skiff lake, 650 feet high by aneroid, a beautiful sheet of water with rocky glaciated islets. Bolton lake, Seeond, Fourth, Fifth and Sixth lakes, First and Second Sheogomoc lakes, Charlie and Davidson lakes have their longitudinal trend north and south to north-west and south-east and show the effects of glacial action in scooping out the boulder-clay or other superficial deposits and forming hollows or depressions, thus producing basins, which caught the drainage waters. Some lakes occupy a depression at the northern base of a stossed hill ; others occur on the lee side where the ice ploughed down more deeply, from its greater momentum, into the superficial materials. Whether any actual wearing or scooping of the solid rocks beneath took place it is difficult to say. There was unquestionably a ronnding of the asperities and a polishing of the surfaces of the rocks, but subaerial decay seems to have been the chief agent in the formation of the depressions. The minor topographical features seem, therefore, to be more or less different from those which existed before the ice age ; but the larger valleys and depressions, such as those of the St. John river, the Cheputnecticook and Magaguadavic lakes have retained their main preglacial outlines.

CHANGES OF LEVEL.

Changes of level.

Very little evidence regarding changes of level has been obtained in this part of the province, as it is not connected with the sea and no shore lines of known marine origin could be found. Although the tides of the Bay of Fundy now affect the St. John river for ninety miles from its mouth, yet it is difficult—indeed impossible at present, to say whether the sea invaded the valley in the Pleistocene period, as different relative levels may have existed then, and no fossils have been found in the surface beds to indicate whether or not they are marine. Notwithstanding this, however, some data showing probable differential vertical movements of an earlier date were observed. As already mentioned, it is possible that the block of land bounded by the St. John, Keswick and Nacawicac rivers was elevated rather more than the surrounding area, especially on the north-west side, and was tilted somewhat towards the south-east. The Lower Carboniferous rocks on the west side of the St. John river appear also to have been unequally uplifted and this movement has in places apparently raised the margin of the overlying gray sandstones to some extent. Such changes of level are probably connected with the intrusion of the granites and trap

rocks of the region. These inferences are, however, based merely on the changed attitude of what must have formed ancient base-levelled plains, and on altered drainage lines. Similar local movements seem to have taken place on the north side of the St. John, especially east of the Keswick valley.

DENUDATION.

Denudation of the middle Carboniferous area.

The gray sandstones of the Middle Carboniferous period which lie nearly in a horizontal attitude throughout the great triangular area seem to the ordinary observer to have suffered no very great amount of surface erosion and waste. But closer examination will reveal evidence of their having been profoundly denuded, and of the fact that their long exposure to the agencies of decay from the period when they first became dry land to the present day has brought about a great reduction of the surface of these sediments. Indeed, it may well be remarked in regard to this large sandstone area, that it forms the best example of base-levelling which we have in Eastern Canada. The nature of the rocks is such that they wear down nearly at a uniform rate, and the slope, though very gentle, has just been sufficient to enable the drainage waters to carry off the waste materials without trenching too deeply. Most of the hollows and valleys have been partially or wholly filled up in the Pleistocene period however, some with boulder-clay, but the lower with marine sediments during the post-glacial subsidence of the country. The general levelling which the area has undergone, denotes a long continued period of subaerial denudation previous to the ice age.

Denudation of the granite areas.

The granite areas within the limits of the map-sheets seem also to have undergone great disintegration and waste. This implies that the rocks, through which they have been thrust up, were likewise deeply denuded. Some of these granite areas, particularly those west of the St. John river are about on the same level as the slates on either side, excepting of course, isolated summits, while granite boulders derived from these, often in trains and ridges, are found upon the surface of the granite belt and of the formations immediately to the south in immense numbers. These boulders are principally due to the deep-seated decay of the rocks in pre-glacial time, and their distribution has been brought about by glacial action and transportation. As it is not probable that when the granites were thrust up into the slates they reached the surface, the principal portion of the latter must have been decomposed and removed before the former could be attacked by the disintegrating agencies. But these granite rocks themselves appear

to have suffered a large amount of decay before they could furnish the waste material which now lies scattered upon their surface and became transportsd southward by glacial action. From these and other facts it is evident that the amount of denudation in this region has been great, and that it extended over a very long time. It is quite probable also, that a large number of the lake basins of southern and western New Brunswick have been produced by this decomposition process, that isby the unequal decay of the rocks, and the scooping out of the materials from the depressions thus caused in their surfaces by the movements of the Pleistocene ice. These depressions, thus emptied of the materials which occupied them, became receptacles for the drainage waters of the region.

GLACIAL STRIATION.

Striation.

The striæ on these sheets, as will be seen from the following list, trend largely from north to south and, as has been inferred in a former report,* were produced by the ice which has been named the Appalachian system of glaciers. This was a glacier or system of glaciers which gathered upon the north-east Appalachians independently, and flowed outward from the higher portions of New England and eastern Canada to the north-east and to the south. No traces of the action of Laurentide glaciers could be found in the area of the two map-sheets under consideration, that is to say, no boulder-clay, nor transported boulders other than those belonging to rocks lying within the drainage basins of the St. John and Miramichi rivers were observed, though diligent search was made for boulders belonging to rocks on the north side of the St. Lawrence. Several different courses of striæ occur in some localities, but they can be best explained by supposing them to have been produced by the same glacier at different stages of its development, or during its withdrawal.

LIST OF GLACIAL STRIÆ.

(The bearings are all referred to the true meridian).

York County.

List of striæ, York Co.

1. On Hanwell road, one mile and three-quarters from Fredericton, S. 47° E. ; height, 150 feet above sea-level.

* Annual Report, Geol. Surv., Can. vol. X. (N.S.), 1897, page 41 *J*.

List of striæ, York Co.

2. Further to the south-west on the same road, S. 25° E. and S. 30° E.; height, 300 feet.

3. At first cross road, on the same road, S. 30° E. Striæ numerous; height, 400 feet.

4. At branch of Garden creek, S. 20° E. and S. 35° E.; height, 330 feet.

5. A mile and a half north of Garden creek, S. 40° E. and S.; slope slightly to north. On opposite side of road, S. 54° E.; height, 450 feet.

6. On Hanwell road about two miles north-east of Hanwell settlement, S. 44° E. and S. 25° E.

7. On road from Hanwell settlement to Indian Village, half a mile north of forks, S. 30° E.; height, 500 feet.

8. Six or seven miles north-east of Harvey on Hanwell road, S. 30° E.

9. At Maryland settlement, on south-west side of North-west Branch, S. 10° E. and S. 5° W.; height, 230 feet. Slope N.E.

10. On road to Maryland, three or four miles south of Fredericton, S. 30° E. and S. 35° E. In another place near, S. 28° E. and S. 35° E. Still nearer Fredericton, S. 28° E.; height, 360 feet.

11. At Doaktown, south-east of Fredericton, S. 30° E.; height, 250 feet.

12. West of St. Marys at south end of road leading to Heron lake, S. 20° E. and S. 28° E., on different exposures; height 50 feet.

13. On Clark's mountain, S. 45° E. Slope S.E.; height, 350 feet.

14. Along Nashwaaksis river near McLeod's mountain, on road to Stanley, S. 25° E. and S. 30° E. Latter most numerous. Slope S.; height, 420 feet.

15. Near Cloddy, S. 35° E. and S. 40° E.; height 400 feet.

16. On Royal road, a quarter of a mile south of Kingsley P.O., S. 40° E. Heavy and numerous, S. 22° E. Lighter. Slope S.W.; height, 390 feet.

17. On road north of Carleton lake, S. 30° E. and S. 11° W.; height, 630 feet.

18. A mile and a half north of Zionville cross-roads, S. 80° E.; height, 255 feet.

19. In Tay settlement several exposures, S. 20° E. and S. 34° E.; height, 400 feet.

20. At P. O., Tay settlement, S. 25° E.

21. South of Birdton, a quarter of a mile south of road to Keswick, S. 35° E. ; height, 730 feet.

22. Near brook to south of last, S. 30° E.

23. On road from Cardigan station to Birdton and north of Jones' Forks settlement (between two brooks), S. 38° E. and S. 40° E. ; slope to W. ; height, 350 to 400 feet.

24. Near junction of this road with parallel road, S. 30° E. ; height, 500 feet.

25. South of Cardigan settlement, near brook, S. 30° E. ; height 715 feet.

26. From one to two miles south of Stanley village, on straight road to St. Marys, S. 80° E. ; height, about 500 feet.

27. Three or four miles south of Stanley village, on road leading down Tay creek and about a mile south of cross roads, S.

Ten rods further south, S. 10° E. and S. 5° E. Several surfaces with the same striæ,—a splendid exposure ; height, 550 feet.

28. West of Stanley village, a mile and a quarter on road to Lime-kiln settlement, S. 10° E. ; height, 390 feet.

29. On road going east from Nashwaak river, on south-east corner of sheet No. 2, S.W., half a mile out, S. 15° W ; slope W. ; height, 430 feet.

30. Just north of the last exposure, other striæ, S. 84° E.

31. On Richibucto road at brook about three miles east of county line, due S. and S. 5° E. ; height, 200 feet

32. On east side of Nashwaak river on road to Lower Durham, at first angle to south, S. 13° W. ; height 305 feet, (Crag-and-tail projections showing southward movement of ice very distinct.)

33. Twenty rods east of last exposure, S. 26° W.

34. On east side of Nashwaak river at cross road half a mile north of Upper Durham, S. 26° W., S. 46° W. and S. 70° W. This is local striation ; height, 205 feet.

35. Along Nashwaak river south of McCallum brook, S. 5° W. and S. 29° W. ; height, 480 feet.

36. In Stone settlement where road from Royal road turns to north-east, S. 30° E. ; slope E.

List of striæ, York Co.

37. At mouth of McBean brook, due E. This is the course of the river valley here, which the ice followed.

38. Half a mile above Hayes brook, N. 25° E. or N. 26° E.

39. Along St. John river, at large stream west of Springhill, near river level, S. 20° E. One mile east of stream, S. 40° E.

40. At Kingsclear, a quarter of a mile from St. John river, S. 35° E.; slope, N.; height, 300 feet.

41. On road leading from Long's creek to Harvey station, Canadian Pacific railway, at second cross roads from St. John river, S. 60° W., or the reverse, stoss side apparently W. ledge broken off abruptly to E. These striæ must be extremely local, the ice which produced them having apparently followed an east-and-west valley very closely. They seem to be very old; height about 400 feet.

42. On the same road about two miles from the St. John river, S. 40° W., S. 10° E. and S. 5° E. The S. 40° W. striæ seem also to have the stoss side to the S.W.

One to two miles from St. John River, S. 10° E. and S. 30° E.; height, 240 feet.

43. On road to Oldham settlement, S. 20° E.

44. At Harvey station, Canadian Pacific railway, S. 25° E.; height, 625 feet.

45. South of Harvey on first cross road to east, S. 27° E.; height, 1,135 feet.

46. Near Cork station C. P. R., S. 25° E.; height, 400 feet.

47. On west side of Bald mountain, Harvey, S. 25° E.; height, 525 feet.

48. About a quarter of a mile north of Harvey station, on road going to Long's creek, S. 25° E.; height, 525 feet.

49. East of Bald mountain, S. 20° E.; height, 520 feet.

50. At north end of Oromocto lake, S. 55° E.; height, 590 feet.

51. A short distance south of last, three sets,—oldest N. 75° E., next oldest S. 15° E., and latest S. 45° E.—all on the same rock surface. These striæ occur on the east slope of a ridge which extends along the west side of Oromocto lake. The N. 75° E. striæ are the heaviest, and are nearly all effaced. The S. 15° E. set are the most distinct, covering the surface of the ledge, while the S. 45° E. striæ

are light and fine. This criss-cross striation occurs in several places in the basin of Oromocto lake. List of striæ, York Co.

52. Near Antimony mines, Lake George, S. 30° E. and S. 20° E.

53. North of Prince William's station, Canadian Pacific railway, S. 30° E.

54. At Jocelyne's brook, S. 10° E. and S. 5° E.; height, 170 feet.

55. Between Lower Prince William and Lake George, S. 30° E. and S. 35° E.; height, 525 feet. Ledges along this road exhibit glaciation continuously for several hundred yards, S. 20° E. to S. 35° E.

56. About half a mile from Cardigan station, C.P.R., on road to Tripp settlement, S. 79° E.; height, 225 feet.

57. Near cross-roads in Tripp settlement, S. 64° E. and S. 87° E. and on another exposure a quarter of a mile north of cross-roads, S. 20° E., S. 44° E. and S. 60° E. Several surfaces occur here between the last-mentioned striated exposure and the bend in the road, S. 64° E.; height at Tripp settlement, 460 feet.

58. On the road from Keswick Ridge to Upper Keswick Ridge, north of second brook, S. 44° E.; height, 280 feet.

59. On the road from Keswick Ridge to Mactaquac stream, a quarter of a mile from ridge road (at red bridge), S. 70° E. and S. 77° E. Several glaciated ledges; height, 200 feet.

60. Near the forks of Nacawicac river, along road leading from Millville to Temperance Vale, S. 40° E.

61. On road from Mapleton settlement to Nacawicac station, C.P.R., (lumber road), two miles west of school-house forks, S. 30° E.; height, 700 feet.

62. At Pike settlement, west of Temperance Vale, S. 5° E.; height, 790 feet.

63. Along the Canadian Pacific railway track, half a mile north-west of Nacawicac siding S. 30° E.

64. At Planeville settlement, about one mile back from St. John river, S. 35° E.

65. On road from Eel River village to Canterbury station, C.P.R., at junction of north and south roads; due S. and S. 40° E.; height, 565 feet.

66. On road from Canterbury station to Hartin settlement, S. 55° E. and S. 40° E.; height, 730 feet.

List of striæ, York Co.

67. On road to First Eel lake, near Graham's Corner, S. 30° E.

68. On Dinnin road, at school-house, S. 40° E.

69. Near cross roads between Grand lake and Forest City, S. 35° E.

70. On the road between Canterbury and Benton stations, C.P.R., north of brook, S. 48° E.

71. On top of Pemberton Ridge, S. 30° E.

72. On road leading from Canadian Pacific railway to Peltoma settlement, three miles south-west of turn of road to Oromocto river, S. 6° W.; height, 360 feet.

73. On road from Scotch lake to Mactaquac P.O., near stream crossing, S. 45° E. and S. 60° E.; height, 450 feet. On another rock surface here, S. 45° E., S. 38° E., S. 28° E. and S. 25° E.

74. About two miles south-east of Upper Queensbury P.O., S. 38° E., and on west side of exposure, S. 20° E.; height, 400 feet.

75. On road going south from Lower Caverhill settlement to St. John river, and just east of a lake, S. 36° E.; height, 650 feet.

76. Near road from Lower Caverhill settlement to Springfield settlement, S. 15° E., also on ledge at cross-roads leading from Staples settlement to this road, S. 18° E., S. 5° E. and S. 15° W.

77. At brook south-east of last mentioned cross-road on Lower Caverhill and Springfield road, S. 28° E. On another exposure near by S. 35° E.; height, 765 feet. These are on the highest part of this road.

78. Near Staples settlement, S. 25° E.; height, 550 feet.

79. South-west of Staples settlement, S. 20° E.; height, 610 feet. In another place near this, S. 30° E.; height, 625 feet.

80. On road from New Zealand settlement to Lower Hainsville settlement, north of former place, S. 55° E.; height, 460 feet. Further north, on granite, S. 65° E. and S. 60° E.

81. West of Scotch lake, one to two miles, S. 40° E.; height, 570 feet.

82. At Mactaquac river, on east side, S. 45° E.

83. On road on south-west side of Keswick Ridge, a quarter of a mile from cross-roads, S. 45° E. and S. 60° E.; height, 250 feet.

84. A quarter of a mile to the north-west of last, S. 20° E. and S. 10° E.; height, 200 feet.

85. At cross-roads east of Scotch lake, S. 48° E. List of striæ, York Co.

86. On road from Mactaquae P. O. to Scotch lake, south of brook running east, S. 30° E. and S. 60° E.

87. Going east on road from Scotch lake, just south of bend in road east of Little Mactaquac brook, S. 40° E.; height, 380 feet.

88. At first cross-road south-east of Mactaquac stream, north of Mactaquac P.O., deep grooves S. 38° E. Lighter striæ, S. 60° E.; height, 250 feet.

89. At next cross-roads to south, on road to Scotch lake, S. 35° E. and S. 50° E.; height, 395 feet.

90. Near cross-roads on west side of mouth of Keswick river, S. 30° E. and S. 60° E.; height, 285 feet.

91. On a hill north of Hayes brook, South-west Miramichi river, N. 30° E., N. 35° E. (Ann. Report Geol. Surv. Canada, Vol. I, 1885, p. 22 GG. No. 65, List of Striæ.) Stoss-side clearly to S.W.; height, 450 feet.

92. One mile from Millville on Howland ridge, striæ S. 35° E.; height, 780 feet.

Northumberland County.

93. At railway cutting near Boiestown, about 200 feet to south of covered bridge, N. 40° E. and N. 50° E. Stoss side, S.W.; height, 200 feet. Northumberland Co.

94. One mile below Boiestown, on south side of South-west Miramichi river, S. 20° E.; height, 260 feet.

Sunbury County.

95. About two miles north of Rushiagonis station, C.P.R., on the road to Fredericton, S. 8° E., numerous parallel grooves; height, 60 feet. Sunbury Co.

96. At end of road in Peltoma or Little Lake settlement, S. 10° E., also S. 60° E. The S. 60° E striæ here like those on the east side of Oromocto lake, are the older and occur along the road for half a mile or more.

97. One mile west of cross-roads in Shirley settlement, S. 32° E., S. 24° E. and S. 10° E.; height, 210 feet.

List of striæ, Queens Co.

Queen's County.

98. Three or four miles north-east of Enniskillen station, C.P.R., S. 30° E. ; height, 460 feet, Several good exposures between this and the old Nerepis road with the same courses.

99. South-east of Enniskillen station, S. 17° E., S. 26° E., on one surface. On another S. 8° E·; height, 310 feet.

100. On the road between Enniskillen station and Patterson settlement, a quarter of a mile from the latter, there is a conglomerate boulder embedded in boulder-clay, three feet of it uncovered and well striated by ice that flowed southward while it was held in this position. Crag-and-tail projections were noted on it.

101. Still further to the south-west on a road not turnpiked and two miles west of cross-roads, striæ due S. and S. 10° E.; height, 400 feet.

102. On the west side of Nerepis river, about one mile south of Armstrong's corner, S. 33° E.; height, 170 feet.

103. At Headline settlement, S. 40° E.; height, 420 feet.

104. At cross-roads in this settlement on road leading to Armstrong's corner, about half way between these two places, S. 28° E. and near by S. 2° E., S. 10° E., S. 15° E. and S. 20° E.; height, 150 feet.

105. Near third cross-road to east of Kelly's brook, S. 28° E., grooves, S. 23° E., 300 feet.

106. A mile and a half south-east of Darby Gillan's on southernmost road, S. 29° E.; height, 350 feet.

107. At Darby Gillan's, S. 25° E. and S. 28° E. Distinct along road for a quarter of a mile ; height, 330 feet.

108. Near Kelly's brook, on road south-east of Darby Gillan's (see No. 106), S. 34° E.; height, 300 feet.

Twenty rods south-east of last, S. 18° E. and S. 25° E.

Carleton County.

Carleton Co.

109. About a mile south of Debec, S. 15° E. and S. 25° E., the first the older.

110. On the road leading from Debec to Monument settlement, just south of cross-roads leading to Blowdown settlement, S. 15° E.

111. On road from Lower Woodstock to O'Donnell's crossing, C.P.R., and equidistant from both places, S. 25° E.

112. On a hill immediately to the east of Greenville station, C.P.R., S. 15° W.

113. On cross-road below Houlton road (Beardsly road), a quarter of a mile from the south end, S. 15° E.

114. On road to Kilmarnock settlement, about three miles from the St. John river, S. 30° E.

115. South of Woodstock, on second cross road, S. 50° E.

116. In Newburgh settlement at border of sheet No. 2 S.E., S. 5° W.

117. At Woodstock (school-house on map), S. 5° E. and S. 50° E. (latest).

118. In Northampton, S. 22° E.

119. In Campbell settlement, north of Trout brook, in several places, S. 40° E. to S. 10° E.

120. One mile south-east of Rockland on Beccaguimic river, on road to Ashland, S. 9° W. Dislocations of two inches in slates here, downthrow to south.

121. At north end of Scott settlement, near brook, S. 21° E. and S. 24° E.; height, 470 feet.

122. On short road running south-east, half a mile south of Little Shiktehawk river, S. 24° W.; height, 580 feet.

123. On the road north of the same river, on first cross road going from St. John river, S. 30° W.; height, 425 feet.

124. About a mile north of Centreville on road to Knoxford, due south.

125. One to two miles north of Greenfield P.O., due south.

126. North of Wiley brook, on road running north from Argyle P.O., S. 55° E.; height, 1,385 feet.

127. South of Bloomfield corner, on road to Lindsay, S. 15° E.

128. On road south of Maplehurst, due south; height, 665 feet.

129. On road one mile north of West Glassville P.O., S. 27° E.; height, 670 feet.

130. Near end of road three miles north of Highland P.O., S. 28° E.; height, 950 feet.

List of striæ, Victoria Co.

Victoria County.

131. A mile and a half east of Perth station, C.P.R., on Tobique road, S. 57° W.; height, 425 feet.

132. South of Red Rapids settlement near Trout brook on cross road, S. 5° W.; height, 840 feet.

BOULDER-CLAY, MORAINES, ESKERS, BOULDERS, ETC.

Glacial deposits.

Boulder-clay is spread over nearly the whole area included in the maps, few localities having been found without it. In certain places, however, it has been largely or wholly denuded, and in these the modified deposits were observed to rest on decayed rock material or solid rock. The heaviest beds of boulder-clay occur in the areas of pre-Carboniferous rocks, particularly in the St. John valley, and along its upper slopes where it has escaped denudation by the river. In these places it sometimes attains a thickness of forty or fifty feet. Between the mouth of the Aroostook river and Upper Woodstock, banks of boulder-clay extend along the west side of the St. John for a great part of the distance. In Prince William, York county, it was observed in a similar position with respect to the river valley. In the parish of Canterbury, heavy beds are massed against the north-west slopes of the hills and ridges, and often envelop them. Many of the lake basins and depressions of the area have been partially filled with boulder-clay during the glacial period, though it has suffered a good deal of denudation since. The Cheputnecticook and Magaguadavic lakes, especially, are dammed and held up by great deposits of boulder-clay, and the islands and points of land running out into them appear to be moraines formed during the final retreat of the ice. On the granite belts, coarse beds of this material were noted, the broad area of these rocks west of the St. John often exhibiting mounds and ridges which are built up of partially stratified material intermixed with large boulders. These ridges have been disposed in various directions, partially by the ice at the retiring stage of the glacial period, and as a result of denudation since.

Boulder-clay in the Carboniferous area.

The boulder-clay on the flat Carboniferous areas seems to be more uniform in thickness, and is practically a continuous sheet, though not as thick as in the hilly districts. In the St. John valley and other places where the thickest beds occur, examinations were made with a view of discovering interstratified deposits, if any existed, but none could be found, and here the boulder-clay seems, therefore, to belong to a single

period of glaciation, or to one system of glaciers, namely the Appalachian, described in my last report.* This conclusion is supported by the fact that no boulders from rocks lying on the north side of the St. Lawrence were anywhere observed, all transported materials having been derived from rocks of the Appalachian system.

The boulder-clay seldom has the drumlin-like form here, though a few ridges south of McAdam Junction, Canadian Pacific railway, and in the Magaguadavic valley might perhaps be characterized as drumlins. In general the outward form of the boulder-clay accumulations is irregular, however, this being either their original outline, or one superinduced by subsequent denudation. These forms are due in many cases to the irregularities of the original rock surface, or to some obstruction in the path of the moving ice.

Eskers or Osars, Kames, Etc.

Eskers occur in the parish of Canterbury and Queensbury, York county, also in Wakefield, Carleton county, and other places. The Eel river, or Monument esker, locally known as 'The Horseback,' was described with a number of others in the report already cited.† It extends from First Eel river lake north-westward into Maine, and is the longest and most remarkable esker in the area. Another long, well-developed esker runs along Deadwater brook, and a third follows Fish creek. These seem to be connected with the Monument esker. The esker along Deadwater brook is a regular south-eastward continuation of these. The latter seems, however, to terminate at the head of this brook, or north of Carroll ridge. Eskers.

An esker occurs in the hollow between Blaney ridge and the ridge immediately south of it.

Another was seen in Staples settlement, near the head of Mactaquac stream.

An esker was noted in the parish of Wakefield, Carleton county, just south of Waterville village.

A remarkable esker was observed on the east side of the mouth of Nacawicac river.

The above are the most noteworthy, but numerous shorter eskers and ridges come under notice in different parts of the area, and a large

* Annual Report Geol. Surv., Can., Vol. X. (N.S.), 1897, pp. 39-48 I.
† Report of Progress, Geol. Surv., Can., 1882-83-84, pp. 20-27 GG.

number of kames or ridges of denudation were observed in river valleys, particularly along the St. John. These are briefly described in the report cited. In the valley of the South-west Miramichi, several short broken ridges (kames) are found at the confluence of the Taxis and this river, their general course being parallel to the latter, and their height above its surface 10 to 15 feet. Mr. Wilson says, 'a kame-like ridge of water-worn gravel, 20 to 30 feet high, stretches along the south side of Hayes brook for a short distance back from its mouth, and below this point, low, narrow gravel terraces occur along the main south-west river.'

Remarks on the Glaciation.

Glaciation comparatively simple in this area.

The glaciation of the area embraced within the two map-sheets here reported on is comparatively simple and seems to have been effected altogether by a single ice-sheet, preceded and followed by smaller local glaciers during the periods of gathering and withdrawal. As already stated, no boulders belonging to the Archæan rocks on the north side of the St. Lawrence were observed in the area under consideration, though carefully looked for. The general course of the ice-movement was south-east, but a few were found trending to the east or north-east. In Carleton county, however, it seems to have been considerably influenced by the St. John valley, which here has a general north to south trend, and hence the flow was nearly due south, occasionally swerving to the east or west in localities where it was affected by the local topography. In York and Sunbury counties, the striæ, as a rule, swerve more to the east, but here we sometimes find divergent courses also, these, however, being, in some instances at least, later, in others, earlier than the general striation. On the east side of the Nashwaak river, for example, we find striæ trending from S. 26° W. to S. 70° W., and on the east side of Oromocto lake, three sets occur, which are occasionally observed on the same rock surface as shown on No. 50 (list of striæ). Here the striæ with the greatest divergence from the north-to-south course is clearly the oldest, notwithstanding the fact that they were produced by local ice in the early stage of the glacial period.

Divergent courses.

Along the South-west Miramichi river, near Boiestown, a number of striæ occur closely parallel to the course of the river valley below that place. Here it would seem that the higher grounds, lying between this river and the Nashwaak, must have caused the divergent courses of striæ observed, the ice on the Nashwaak side of these grounds

flowing south-westward, while that gathering on the north-east flowed as above indicated.

MODIFIED INLAND DEPOSITS.

Stratified deposits.

Although it is difficult to conceive of the sea not having occupied a considerable part of the area included in these map-sheets in the Pleistocene period, much of the eastern part being below the 220-feet contour-line above mean tide level, yet the absence of marine fossils renders the question doubtful. Clays, sands and gravel deposited in the order in which they are found in coast districts, and similar in every respect to the Leda clay and Saxicava sands, were observed everywhere below the contour line mentioned, and in some places above it; but the only organic remains hitherto met with are those of a fish in the clays of Ryan's brickyard at Fredericton, which have not yet been identified and may be either fresh-water or marine. In the present condition of our knowledge, therefore, in drawing this contour line on the map, it is best to leave open the question as to whether the stratified beds below the contour line referred to are of marine or fresh-water origin.*

Terraces.

Besides the river and lake terraces, and kames or gravel ridges which will be described on a later page, deposits of gravel and sand, often of considerable thickness, and sometimes with clay beneath, occupy the greater portion of the surface of the region, and mainly constitute its arable lands. Occasionally these exhibit an even and regular surface, but for the greater part they are more or less undulating and conform to the contours of the boulder-clay and rock surfaces beneath, though of variable thickness. Boulder-clay generally underlies them. The deposits of this character are not so abundant here, however, as upon the districts bordering the Bay of Fundy. In the coastal tract great quantities of coarse gritty material, derived from the ancient crystalline rocks, are scattered about in certain localities, constituting a marked feature of the surface beds. In north-western New Brunswick, however, these gravels and sands are of much finer texture and form good soil. Their occurrence on the summits of ridges and elevations, apparently beyond the reach of marine, lacustrine, or fluviatile action is difficult of explanation, unless on the supposition that they were produced by the waters flowing out from the melting glacier or glaciers during its retreat. On some of the slopes they have probably

Coarse gravel and sands.

* The uppermost limit of the marine deposits along the coast of the Bay of Fundy is 220 feet above the sea. (See Report, on the Surface Geology of Southern New Brunswick, Annual Report, Geol. Surv., Can., Vol. IV. (N.S.), 1888-89).

been caused by atmospheric wear and waste, the materials having been loosened by frosts and rains, and in their movement to lower levels year after year have assumed a stratified structure. In these, the finer materials, such as clay and silt, would be carried farthest from the source to lower tracts and form lenticular beds such as are occasionally observed.

River and Lake Terraces.

River and lake terraces.

The terraces along river valleys and on the borders of lakes, composed of stratified materials, have been produced by fluviatile and lacustrine action. The former are well developed in the valley of the St. John, and a large number of them have been described in the report already cited.* They often form a series of from two to five steps or benches along the river's bank and are very beautiful when cleared of forest and clothed in a green sward. The highest are evidently the oldest. Between Woodstock and Grand Falls the terraces are found at elevations of 100 feet to 180 feet above the St. John. The lower are known as river flats or meadows, and have generally a capping of loam. All the terraces seem to have a slight grade down stream, that is, longitudinally, and none were observed of greater length than two or three miles; usually they are much shorter.

How river terraces were formed.

How were the higher terraces formed? This is a question often asked, but not easily answered. That the river, with an open valley, as it has at present, was flooded to the height of the uppermost of these is quite impossible; that it flowed at that level, however, is indisputable, as the terraces are certainly of river formation. The following brief explanation, based on the facts collected in the field, although not new, is tentatively offered.† Previous to the glacial period, the St. John seems to have had its channel as low as it is at present; perhaps, even lower at some places. The glacial period ensuing, the river valleys and depressions were filled partially or wholly with boulder-clay or morainic materials. On the withdrawal of the ice, these barriers in the river valleys obstructed the drainage to such an extent that the rivers had to flow at much higher levels than previous to the glacial period, and probably formed a series, or chains, of lakes along the valleys. Erosion and transportation of the material then began. But though a large portion of the boulder-clay which occupied the valleys has since been carried away and laid down as stratified deposits at lower levels, an occasional barrier, such as that occurring

*Report of Progress, Geol. Surv. Can., 1882-83-84, pp. 27–42 GG.

†*Ibid*, pp. 41–42 GG.

at Grand Falls, is still found, where the St. John has been entirely diverted from its old channel and forced to cut a new one, three-quarters of a mile long in solid rock. It was during the early erosion of these boulder-clay barriers across the river valleys that the higher terraces along the banks were formed in the intervening portions of the valleys. As the process of erosion went on, the rivers reached lower and lower levels and after a time began cutting down into the first-formed stratified beds, transporting the materials still lower down and forming other terraces. These changes have been continually in progress since and the result is, the beautiful series of terraces seen along the banks of the St. John and its tributaries.

In the erosion or cutting down either of the boulder-clay barriers, or of the earliest formed stratified beds, certain portions were left along the sides or river banks which escaped denudation. But besides these, ridges were occasionally left in the centre of the valleys which now form islands, or as I have called them in previous reports, kames. Their more modern representatives are the long, low, narrow islands of river courses. The St. John valley in the Andover and Grand Falls sheets contains the best developed terraces met with along its whole course. The widest are never more than 400 or 500 yards, and the greater number seldom exceed 100 to 150 yards, and, as has been stated, they are of various lengths longitudinally or up and down river. The lower terraces being covered with loam, are called river-flats, and form good arable lands, the higher being generally composed of coarser materials, constitute a poor soil. The terraces along the tributaries are of the same character as those of the St. John valley itself, but are not so well developed nor as high relatively to the adjacent river or stream. The rule laid down in the report already cited, namely, that the width and length of terraces depend on the size of the river, seems, generally speaking, to hold good. In this respect the terraces are very closely related to the post-glacial rivers of this part of Canada.

Great development in St. John valley.

Terraces along tributaries.

Relation of the Inland Stratified Deposits to those of Marine Origin along the Coast.

On a previous page the classification of the stratified inland-deposits was referred to and the difficulty of assigning to them a fresh-water or marine origin was briefly discussed. It was pointed out that unless fossils were found in them they could not be satisfactorily correlated with the known marine coastal beds. There is, however, one aspect of

Relation between inland and marine deposits.

the question to which attention might be directed, as tending to show that such a view should only be tentatively held, and that the absence of fossils does not always prove that such deposits cannot be marine.

In a former report it was pointed out that the beds representing the Leda clay and Saxicava sands, which rest on the Carboniferous sandstones of the coast of New Brunswick are unfossiliferous, or at least no marine shells or other forms of life have yet been found in them. Only in a few localities on the west coast of Prince Edward Island have Pleistocene marine fossils been found in the whole Carboniferous basin, though a large area now forming dry land must have been under the sea, which was doubtless then, as at the present day, inhabited by marine animals. How is it then that these coastal beds, supposed to have been laid down in an area of comparatively shallow waters, and which must have contained the shells of species then living in these coast waters, do not contain them at the present day? The answer would seem to be that the arenaceous clays and the sands which together constitute the stratified deposits lying below the uppermost shore-line of the Pleistocene submergence contain minerals destructive to shells and the tests of marine animals. The absence of lime in these deposits, the quantities they contain of iron, both as an oxide and a sulphate, and their porous character, all conduce to bring about a somewhat rapid and complete dissolution of the animal remains buried in them, and consequenly the beds now appear as wholly destitute of fossils. If these beds, which we now know are marine from their proximity to the coast and their occurrence below the highest Pleistocene shore-lines, were met with in the interior of the country, their mode of origin would be as problematical as that of the deposits in the St. John valley referred to. Both are of similar composition and, so far as can be judged, of the same age, and both unfossiliferous. Why then may not the deposits in the St. John valley occupying the Carboniferous area, a large portion of which lies below the level of the uppermost marine shore-line of the Bay of Fundy and Northumberland Strait, have not also been of marine origin? A low watershed crosses the country in a north-east and south-west direction separating the waters which flow into the St. John from those which fall into Northumberland Strait. This watershed does not appear to have presented a closed barrier in the Pleistocene, however, but probably allowed the sea to invade the St. John valley, especially in the region of Grand and Washadamoak lakes; and if the relative levels of the coast districts and the interior were even approximately the same then as at the present

Absence of marine fossils.

Annual Report, Geol. Surv., Can., Vol. VII. (N.S.), 1895, pp. 112-114 M.

day, a passage for the sea would also exist by the St. John river valley. The sea would probably enter the interior of the province by these and form a bay covering a large area in which the lakes above mentioned now lie, extending up the valleys of the St. John, Oromocto, Nashwaak, etc. If such a bay or interior sea existed here in the Pleistocene it would, of course, leave shore-lines at the 220-feet contour line above sea level, unless a differential uplift or subsidence took place. Shore lines at the supposed limit of submergence were, however, observed only in a few places.

Though the deposits under discussion lying below the 220-feet contour line may thus be correlated to some extent with those of known marine origin along the coast, yet it cannot be stated with certainty that they constitute the equivalents of the Leda clay and Saxicava sand, and in the present state of our knowledge concerning them, it is considered best to map them as interior deposits.

FRESH-WATER DEPOSITS OF THE RECENT PERIOD.

River-flats (Intervales).

River flats along the St. John.

The lowest of the terraces which skirt the St. John and its tributaries, and which are usually the widest and longest are called river-flats or intervales. In the eastern part of the Fredericton sheet they form areas of arable land of considerable extent, on both sides of this river, more especially at Maugerville, Lincoln, at Nashwaak, etc. Above Fredericton and St. Mary's they narrow towards Springhill and Clarke's mountain, but expand again, at the mouth of the Keswick river. This river discharges into the St. John in the midst of wide intervales and among islands noted for their excellent soil and agricultural capabilities. From the Keswick up, they are comparatively narrow, but widen locally in a few places, as for example at the Barony, at Southampton, Woodstock, Florenceville, Perth, Andover and Aroostook Junction. Several islands also along this part of the river are under cultivation and yield large quantities of hay. These and the flats are overflowed by spring freshets occasionally and a thin layer of clay and silt deposited, which serves to enrich them. This material, which is a sandy loam, is often several feet deep, and, being rich in decayed vegetable matter, contains all the elements of a fertile soil.

PEAT BOGS.

Peat bogs.

Although peat bogs are found in many places within the area of the two map-sheets they are mostly small, and have not yet been utilized in any way. A few of those which contain peat in quantities sufficient to be of economic importance may be enumerated.

A bog containing excellent peat lies between Lower Spruce Peak and Howland Ridge, north of Millville.

Another occurs at the head of Mactaquac stream.

A bog, or peaty barren of considerable extent, was seen along Pokiok river, west of the settlement of the same name.

Several small bogs were observed along the St. Andrews and Woodstock branch of the Canadian Pacific railway, especially south of McAdam Junction, also to the east, in the vicinity of Magaguadavic lake.

Similar boggy formations were likewise noted among the sand hills at the mouth of Oromocto river.

AGRICULTURAL CAPABILITIES OF THE AREA.

Agricultural character of the area.

A description of the agricultural character of the area under consideration was given in the report already several times cited,* and but little can be added to it except as regards the north-eastern portion. A considerable number of new settlements have, however, been opened up since the date of that report, and some others extended, principally on the east side of the St. John, in York, Carleton and Victoria counties. West of the St. John the country is thickly settled, except upon the areas of granite and millstone grit, where large tracts are still under forest. In Carleton and Victoria counties the land on the west side of the river is similar to that of the Aroostock valley across the International boundary in point of fertility, and is of excellent quality.

Settlements along the east side of the St. John.

On the east side of the St. John the principal settlements within the area of the Fredericton sheet are along the Nashwaak river and northwards in a belt twenty miles wide or more following the St. John valley. A large tract to the east of the Nashwaak is unsettled. In the region embraced in the Andover sheet, settlements are seen near Boiestown, on the South-west Miramichi, and at Stanley. The

* Report of Progress, Geol. Surv., Can., 1882-83-84, pp. 42-44 GG.

whole of the northern part of York county and of the north-east of Carleton and Victoria counties, nearly to the Tobique river, is unsettled and forest-clad. Mr. Wilson thus remarks on the surface deposits and agricultural character of the part of the region drained by the South-west Miramichi river :—'The greater part of the area being covered with a heavy forest growth, few opportunities are given to study the surface deposits. In the settlements along the south branch of this river, rotten rock is frequently seen, the upper part modified and in places forming a rich soil ; only very small areas of boulder-clay were noted, but travelled boulders, well rounded, are common. Between the Taxis river or Greenhill settlement and the main south-west, and in Pleasant Ridge settlement on the east, the soil is generally gravelly with occasional boulders of granite, gneiss, etc., though on the ridges between the streams, which are comparatively level on the summit and in most places free from stones, it is a deep loam with areas of clay in places. In some localities, however, the erratics are too common and interfere with the cultivation of the soil. No large area of boulder-clay was seen in these settlements, but the presence of striæ at Hayes brook, as well as the general distribution of transported boulders, bear evidence of glaciation. On the portage between Pleasant Ridge settlement and Dungarvon river, several large tracts of good farm land were seen, and similar belts are said to occur on the north branch of the South-west Miramichi.

Mr. Wilson's remarks on the south-west Miramichi valley.

'The country north of the main river drained by Burnt Hill brook and other adjacent streams, is not suited for settlement, though there are small areas of good land ; for the most part, however, it seemed to be stony and the soil poor. Cedar swamps are common throughout the district, and these are useless as farming lands. Unfortunately, the whole area is held for lumbering operations and is not available for settlement, and the heavy growth of hardwood would also make it difficult and expensive to clear for cultivation. These two obstacles apply to nearly all the best agricultural land in the south-west Miramichi valley.'

In regard to the general character of the land in the part of the province embraced in the two map-sheets, it appears that while much of it is of an excellent quality, other parts are poor and comparatively useless for agricultural purposes. The best is that known as meadow land (river flats or intervales), which occur along the St. John and its chief tributaries and on the Miramichi. This was described in the report referred to and occupies in the aggregate an area of not less than

Quality of the different kinds of soils.

60,000 acres.* All this is under cultivation, much of it yielding hay, which it produces year after year without the addition of any fertilizer.

On Silurian limestones.

Next in importance and in point of fertility to the meadow land are the uplands resting on the Silurian slates and limestones, which extend over a large part of western and north-western New Brunswick. In the area of these uplands on both sides of the St. John river, the principal settlements exist, and many excellent farms can be seen. The underlying rocks generally wear down into a calcareous, somewhat porous soil, well suited for producing mixed crops and for horticultural purposes, hence it is well adapted to the climatic conditions of this country.

On Cambro-Silurian.

Excellent lands likewise rest on those wide belts of rocks mapped as Cambro-Silurian. These rocks, however, often decompose into a clay soil, which in some places is so compact as to be impervious to water. It is not, therefore, so well suited for general crops as the more porous soils of the meadows and Silurian uplands, but is, nevertheless, good for cereals and hay. Some parts of the country occupied by these rocks are stony and boulder-strewn, and unfit for settlement. This remark applies more particularly to the districts east of the St. John river and north of the granite belt. The band of these rocks stretching along the south-east side of the granite contains much good arable land on both the areas of the Fredericton and Andover sheets. In Stanley, York county, and Ludlow, Northumberland county, large tracts of it are still under forest, but the soil, though reported to be heavy, is rich, and wherever cleared yields abundant crops.

On the Carboniferous.

The areas occupied by Carboniferous sandstones as shown in the eastern parts of the map-sheets (No. 1 N.W. and No. 2 S.W.) are characterized by a sandy and gravelly soil in some places, in others they are clayey and heavy. These uplands not infrequently have a sort of hardpan, consisting of boulder-clay beneath the surface, and consequently are sometimes wet and swampy, except in places, where there is sufficient slope to afford good drainage. A large part of this flat-lying sandstone area within the St. John drainage basin is but little elevated above the valleys of the chief rivers which drain it and has a deep soil. On the low watersheds peaty areas usually occupy the surface. The materials which compose the soils and subsoils upon these carboniferous rocks, being largely due to the decay of the underlying strata, contain little or no lime, and hence fertilizers containing this and vegetable or other organic matter should be frequently applied to these lands.

* Report of Progress, Geol. Surv., Can., 1882-83-84, pp. 42-44 GG.

Upon the granite areas, the land is, for the most part, unfit for cultivation, containing numerous boulders of all sizes up to ten feet in diameter, the soil consisting usually of a coarse gritty debris derived from the underlying rocks. East of the St. John river, however, there are some farming districts located on these granite areas in which we observed good soils and thriving crops, but they were found almost invariably in localities where the ice of the glacial period had transported material thither from the Cambro-Silurian and Silurian rocks to the north-west and thus enriched them. Settlements on these lands may be seen at New Zealand, Springfield, Queensbury, Lower Southampton, etc. On granite areas.

FORESTS.

Although it was in this part of the province that the earliest settlements were founded more than a hundred years ago, yet large portions of the area of the two map-sheets under consideration, including some of the best arable lands, are still unsettled and under forest. A glance at the maps accompanying this report, on which the forest-covered areas are depicted, shows better than any written description can do the character and extent of the forest resources of this part of New Brunswick. On the Andover sheet alone an area not less than three-fourths of the whole, principally in the north, east, and central parts is still occupied by a heavy growth of the original trees which existed here when the country was first settled. Extent of forest covered land.

Following the rule laid down formerly in regard to mapping the forests, we find that in the region under consideration they can be classed in two main divisions :—(1) the original growth or that which existed here at the time the first settlements were formed, though considerably thinned out and depleted by lumbering operations and other causes, and (2), the recent or second growth which sprang up in districts where the older trees had been destroyed by fire or entirely cut away. In many of the places last referred to, where the land is useless for farming purposes the old forest growth should have been preserved, and if some reasonable foresight had been exercised, might be a valuable asset and a source of revenue now. Some of these tracts never were and never will be of any use for agricultural purposes, and have thus been allowed to go to waste as regards forest production. The extensive belt of wooded country known as the central highlands of New Brunswick, which too, is altogether unsuited for agriculture, will probably have its forest growth largely depleted in the near future How mapped.

unless immediate steps are taken to conserve it. Eventually all the arable lands of the province will be taken up, and denuded of forest as settlements advance. This large interior tract should, therefore, be set apart now as a forest and game reserve, before too great inroads are made upon it. For a provincial park and a sporting ground for hunters and fishermen it has no equal near the Atlantic coast of Canada.

A provincial park.

Chief trees of economic importance.

The chief trees of economic value in the area of the two map-sheets are well known, and consist of spruce, hemlock, pine, fir, larch, cedar, etc., of large enough dimensions for commercial purposes; and black and white birch, maple, beech, ash, poplar and others. A few trees of the American linden (*Tilia Americana*) were found growing on the banks of the St. John river below Woodstock, and the walnut, (*Juglans cinerea*), rare or wanting in most parts of the province, occurs in clumps on hillsides in the same vicinity. Elms, often of large size were seen on the intervales and slopes of the river valleys in all parts of the region. In the large forest-covered area of the Andover sheet only limited belts and patches on the east side of the Tobique, and along Burnt Hill brook and McKeel brook on the South-west Miramichi and north of the north branch of the Beccaguimic river show a second or later growth, these tracts having been overrun not many years ago by forest fires.

Mr. Wilson's notes on the forest of the south-west Miramichi valley.

The following notes on the forests of the upper South-west Miramichi are inserted from Mr. W. J. Wilson's observations. 'The greater portion of the area is covered by a dense forest which supplies large quantities of lumber every year. Except in comparatively small areas the forest is composed of original growth. In the south-east portion of the Andover sheet at the head of Cains river, second growth prevails and only occasional clumps of old trees can be seen, although even in this district considerable lumber is cut. Quite an extensive area of burnt land covered with second growth extends along the east bank of Burnt Hill brook, and two other large areas occur on McKeel brook. The latter were recently burned and a large quantity of valuable lumber destroyed. In the eastern part of the sheet, going northward from Pleasant Ridge settlement, spruce with occasionally cedar, etc., prevails for the first four miles; from that point to the Dungarvon river, hardwood ridges and spruce swales alternate every mile or two, the hardwood occupying the ridges between the streams and the spruce woods the river valleys and lower ground. Spruce, however, is generally found mixed with the deciduous trees on the hardwood ridges and when so found is said to make the best lumber, as it is more likely to

be sound and firm. Hemlock was also noted as common on this route. Along the portage road from Green Hill settlement to the Miramichi river the conditions are much the same as on the road just described, except that there are large areas of hardwood, the woods, for the most part, being open and free from underbrush. Black birch measuring from seven to ten feet in circumference, rock maple, six feet and a half, beech, five feet, spruce, six feet and a half, estimated seventy to eighty feet high, and cedar, six feet, around the base of the trunk were noted in this section.

'Along the portage road one to two miles west of Burnt Hill brook the forest is chiefly spruce and fir, with here and there a hardwood ridge, and the same holds true for the country east to Clearwater brook, and down to the Miramichi river by the portage along the Sisters brook, except that near the Miramichi river there is more hardwood. This forest is the scene of active lumber operations, and has been for many years past. The young spruce grow very fast, especially when the larger trees are cut away; and lumbermen go over the same ground every eight or ten years.'

Destruction of the forest on the Carboniferous areas.

On the Fredericton sheet the Carboniferous area has been largely denuded of its original forest growth, and a recent one has replaced it in most localities not cleared and settled. This condition of things is chiefly due to old forest fires. The gravelly and sandy nature of the soil, and the fact that coniferous trees predominate on these lands render the forests occupying them particularly liable to conflagrations in dry seasons. On the granite belt and the tracts lying to the northwest of it the sylvan growth is mostly original, except near railways or old settlements. A strip of second growth follows the St. Andrews and Woodstock branch of the Canadian Pacific railway from the southern border of the sheet nearly to Debec Junction. On the east side of the St. Croix river and Cheputnecticook lakes there is another belt of recent forest, doubtless the result of a destruction of the older trees by fire, also a third along the Gibson and Woodstock branch. These belts together with a patch along the Mactaquac stream constitute the principal areas occupied by a recent growth, all other parts of the wooded country included in this sheet being occupied by the old growth. Much of this old forest has, however, been more or less depleted of the larger timber trees by lumbermen under the regulations of the Crown Lands Department of the province. So long as these forest areas can be preserved from fires, merchantable lumber can be obtained from them by re-cutting the larger trees at intervals of every twelve or fifteen years. Though thus partially thinned out

these large areas of forest lands, nevertheless, form an important asset in the natural wealth of the province.

ECONOMIC MINERALS AND MATERIALS.

Minerals of economic value.

A number of minerals of economic importance occur in the area described, the principal being iron, both hæmatite and limonite, or bog iron ore. The largest beds of hæmatite are those of Woodstock or Jacksontown, which were wrought at intervals between 1848 and 1884. In connection with these iron mines, a blast furnace was erected at Upper Woodstock, where the smelting of this iron, together with the bog iron ore from Maugerville, Sunbury county, was carried on for some years. Considerable quantities of hæmatite still exist in the vicinity of Woodstock.

Bog iron ore.

Bog iron ore is found at Maugerville and Burton, Sunbury county. At the former place occur what are probably the largest deposits in the province. They were examined by me in 1882-83, when pits were opened and work going on. At that time considerable quantities of this mineral were being taken from this place to Woodstock, as mentioned above, to be mixed with the hæmatite ores in the blast furnace then in operation there. Since the Woodstock iron works were closed, however, no use has been made of the Maugerville ore. This mineral is said to occur in the bank of the South-west Miramichi river, one mile below Clearwater brook and nineteen miles above Boiestown, but the extent of the bed has not been stated.

Bog manganese.

Bog manganese is found in small quantity in a gravel bank near the old Government House, Fredericton. It is also reported from Queensbury, York county, and from Lincoln, Sunbury county, but the deposits at the last two places were not seen.

Mr. W. McInnes, of this Survey, reported this mineral from the north branch of the South-west Miramichi, twelve miles and a half above the forks, in a deposit on the river's bank.

Antimony.

Stibnite, or sulphide of antimony, occurs in the parish of Prince William, York county, near Lake George, where it was known to exist as early as 1833. It has been wrought at intervals till about the year 1890, but from all that can be learned, without profit.

Gypsum.

The gypsum deposits of the Tobique valley, which lie just to the north of the Andover sheet, contain extensive seams of coarse plaster, but, except for fertilizing purposes, the gypsum is not as good as

that of Hillsborough. Work is carried on here also in a desultory manner, the sale of the product being limited.

Gold. Gold has been reported from Cross creek and Stanley for many years, and at periodic intervals an excitement is aroused from some supposed new 'find,' followed by more or less prospecting, buying of claims, etc. The last of these took place in the winter of 1898-99. In the following autumn the writer made an examination of this district, but could find no gold at Cross creek, either in the gravels or in the matrix. In the Nashwaak valley, near the village of Stanley, however, a few very fine particles were washed out of the sands in the bed of the river, and also at the mouth of Yerxa brook, where some prospecting seems to have formerly been carried on. These particles were rough and did not appear to have been transported any distance, and there are doubts as to whether they really belong to the district. It is possible they may have been dropped by prospectors and others who have been panning the gravels here at various times within the last thirty or forty years.

Brick clay. Brick clay is common everywhere in the district, but only two kilns were in operation in 1898-99, namely, Ryan's, at Fredericton, where considerable quantities of brick are manufactured, and another at Grafton, opposite Woodstock. These, however, do little more than supply the local demand, which is not great.

GEOLOGICAL SURVEY OF CANADA
ROBERT BELL, M.D., D.Sc., LL.D., F.R.S.

NOTES ON CERTAIN

ARCHÆAN ROCKS

OF THE

OTTAWA VALLEY

BY

A. Osann, Mülhausen, Alsace.

(Translated from the German by Nevil Norton Evans.)

OTTAWA
PRINTED BY S. E. DAWSON, PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1902

12 o

No. 763.

NOTES ON CERTAIN

ARCHÆAN ROCKS

OF THE OTTAWA VALLEY.

By A. Osann, Mülhausen, Alsace.

(Translated by Nevil Norton Evans.)

Field of investigation.

In the autumn of 1899, in compliance with a request from the Geological Survey of Canada, I made a series of geological excursions extending over five weeks, in that part of the province of Quebec north and east of Ottawa, and in this I was assisted in the most obliging manner by Dr. Dawson, then director of the Survey. Further, upon many of these excursions I was ably directed by Dr. R. W. Ells and by Mr. E. D. Ingall. It is a pleasure in this place to express my warmest thanks to these gentlemen.

Nature of work.

The object of these excursions was, on the one hand, to become acquainted with some of the principal types of gneisses and their associates, and on the other, and more especially, to study the technically important minerals apatite, mica, and graphite. Naturally, on account of the great variety of the gneisses and the enormous area covered by them as well as on account of the short time at my disposal, it was necessary to select certain characteristic types. Their further geological study, and the determination of their relations, must wait for a special mapping of this highly interesting district. Relatively the longest time was given to the study of the apatite deposits.

CERTAIN GNEISSES FROM THE NEIGHBOURHOOD OF OTTAWA.

Fine section of gneiss.

On the right bank of the Ottawa river, south of Montebello, a station on the Ottawa and Montreal branch of the Canadian Pacific railway, a very fine section has been opened up in the gneiss. The gneiss is here interstratified with quartzite and granular limestone, the gneiss

being below and the limestone above the quartzite; the principal strike is N. 70° E., and the dip 30°-40° to the south. The gneiss is very much bent and folded, as may be easily observed on the surfaces which have been highly polished by ice. The macroscopic character of the gneiss reminds one strongly of the hornfels gneiss in the southern Odenwald and of many so called Rench-gneisses of the Black Forest; in hand specimens it is often impossible to distinguish it from these. Characteristic signs are the following: moderately fine and very even grain, great abundance of mica, and a mica-schist habitus caused thereby. Further, lack of flaser or augen structure; the constituents are very uniformly distributed, the mica plates are all arranged parallel, so that the rock breaks fairly well in this direction. The regularity of the structure is only interfered with by numerous quartz veins and nodules which are frequently as thick as one's finger and thin out to nothing in short distances. The mica of the normal rock is a reddish-brown biotite, but in many of the beds there occurs also a white mica on the schistose surfaces; this is not uniformly distributed but forms rosette-like aggregations. Many of these latter exhibit a roughly six-sided outline, so that in all probability they are pseudomorphs after staurolite or cordierite. In all other respects the rock seems to be perfectly fresh.

Macroscopic description.

Under the microscope, the gneiss is seen to be very rich in feldspar. By far the larger number of the sections of feldspar exhibit the crossed twinning of microcline; frequently in one grain the 'cross-hatching' passes over into undulatory extinction and uniform orientation. Sections free from lamellæ do not differ in refraction or microstructure from the striated ones and belong in all probability to the same feldspar or orthoclase.

Feldspar and mica abundant constituents.

Mica occurs in quantities almost equal to the feldspar. In sections parallel to the lamination it exhibits irregularly rounded and ragged forms, and in sections at right angles it is often bent and opened up. The pleochroism is very characteristic, the colours varying between a bright reddish-yellow and dark reddish-brown; basal sections exhibit no marked differences in absorption. The inclusions in the form of small colourless rounded grains and small crystals of high refractive index and high double refraction are zircons; around these there is generally a dark non-pleochroitic area.

A further constituent occurring in considerable quantities and which may often be seen with the magnifying glass is tourmaline. It forms short stout columns, 0·1—0.15 mm. in diameter and 0·3—0·4 mm. in

length, but the dimensions decrease from this down to extreme smallness. O is brownish-green; E, colourless with a touch of red.

Colourless mica, as already stated, is confined almost entirely to certain little aggregations; in the normal rock it is very rare and makes up larger flakes in poikilitic intergrowth with the other constituents of the rock.

Quartz, with the usual fluid inclusions, occurs much more sparingly than feldspar and mica. Apatite and ores are rare; and rutile as well as graphite and other carbonaceous materials are absent.

Typical hornfels structure.

The structure, especially in those parts poor in mica, is that of a typical hornfels; in portions rich in mica, especially in sections cut vertical to the schistosity, it is more or less hidden by the parallel arrangement of this mineral. The uniform size of the grain and the extreme freshness of all the constituents of the rock under the microscope is remarkable. The whole macroscopic and microscopic character of the rock is that of a typical paragneiss, that has been formed by the metamorphosis of a sedimentary rock, probably a clay slate. An analysis was made by Dr. Dittrich, and is given under I.

	I.	II.
SiO_2	58·68	57·66
TiO_2	1·39	—
Al_2O_3	16·17	22·83
Fe_2O_3	1·66	—
FeO	5·69	7·74
MgO	3·71	3·56
CaO	0·30	1·16
Na_2O	0·83	0·60
K_2O	8·68	5·72
P_2O_5	0·31	—
CO_2	0·36	—
H_2O	1·65	1·59*
Total	99·43	100·77

Analyses compared.

For comparison there is given under II an analysis of a sillimanite-bearing gneiss, rich in biotite, from Trembling lake, according to Adams, to whom we owe very valuable investigations into the gneisses from a large area north of Montreal. Both analyses are very similar except in the larger quantity of alumina and smaller quantity of alkalies in No. II, a peculiarity which is explained mineralogically by the occurrence of the pure silicate of alumina, sillimanite, in the gneiss from Trembling lake. No. I shows the same percentage of silica, but

* Loss on ignition.

is poorer in alumina and richer in alkalies, corresponding to its content of tourmaline. III gives the molecular proportion of I reduced to 100, excluding the water and carbon dioxide and calculating all iron as protoxide.

	III.	IV.	V.	VI.	VII.
$Si O_2$	67·01	67·60	66·83	83·33	68.55
$Ti O_2$	1·19	0.35	0·45	0·20	—
$Al_2 O_3$	10·86	9·05	9·61	7·54	14·60
Fe O	6·83	3·74	3·69	1·22	2·49
Mg O	6·35	7·69	5·96	—	0·14
Ca O	0·37	3·51	5·35	0·35	0·48
$Na_2 O$	0·92	6·40	4·57	3·95	10·15
$K_2 O$	6·32	1·61	3·12	3·41	3·52
$P_2 O_5$	0·15	0·05	0·15	—	—

V. with 0·08 Mn O.
0·12 Ba O.
0·07 Sr O.
VII. with 0·07 Mn O.

Characteristic resemblance of analyses.

For both analyses I and II the small quantity of lime in proportion to the large quantity of magnesia and small quantity of silica is characteristic. Further, the total alkalies and lime are far from sufficient to form with the alumina the molecules $(K. Na)_2 Al_2 O_4$ and $Ca Al_2 O_4$. Mineralogically this is explained by the completely unaltered character of the rock, and by the silicates of alumina being free from or poor in alkalies, such as sillimanite and tourmaline. A glance at the analytical tables of plutonic rocks arranged according to molecular proportions (2) shows that such a small content of lime as there is in III only occurs in the case of highly acidic granites and a few elæolite-syenites. In the former case the $Si O_2$ (in molecular proportions) is over 80%, in the latter alumina and alkalies are decidedly higher. For comparison the following are given :—

IV. Analysis of Kammgranite Vogesen.
V. " Syenite from Yogo Peak, Montana.
VI. " Granite from Cape Ann, Mass.
VII. " Elæolite-syenite from Litchfield, Me.

Analyses given for comparison.

Of these, IV. and V. have about the same proportion of $Si O_2$, $Al_2 O_3$, and alkalies as III. ; on the other hand the proportion of lime is considerably higher. VI. has about the same proportion of alkalies and lime ; but alumina, iron and magnesia are lower and silica considerably higher. In VII. silica and lime are as in III., but alumina and alkalies are more plentiful, magnesia and iron much lower. Rosenbusch first pointed out that such a small proportion of lime with relatively large quantities of iron and magnesia are characteristic of normal

clay slates, as is also usually the pronounced preponderance of potash over soda. Provided that during the metamorphosis of such slates, their chemical composition is not altered or only slightly changed, as has been observed at least in the case of contact metamorphosis on several occasions, the supposition that the Montebello gneiss has been formed from a clay slate is quite in harmony with its chemical composition. It must not however be forgotten, that as has been often observed in the case of plutonic rocks, by normal decomposition a rapid removal of lime and soda occurs, here also the same chemical character results. Most of the old Palæozoic and Archæan clay slates obtained their material mainly from eruptive rocks and eruptive gneisses, so that a leaching out of lime and soda by the weathering during the transport and grinding up of the original material must have taken place, while in the case of plutonic rocks that have not been so mechanically disintegrated, this chemical process will have taken place much more slowly and less completely. The general process is, however, the same in both cases. The above analyses therefore furnish merely a certain probability of the sedimentary character of the Montebello gneiss.

Montebello gneiss of sedimentary origin.

The quartzite from Montebello, consists for the most part of a coarse aggregate of quartz grains, which abut against one another with irregularly angular and toothed margins. No indications whatever of clastic origin or of later orientated growth, &c., can be recognized; a cement is also wanting. Widely distributed, however, are the well known evidences of pressure such as undulose extinction and the breaking up of larger grains into a number of smaller ones of approximately the same optical orientation. Further the streaked appearance, so often described as suggesting twinning lamellæ, is not uncommon. The streaks can be recognized in ordinary light; in part they are as clear as water, in part dull and filled with interpositions looking like dust. Some of these, upon strong magnification are found to be fluid inclusions.

Composition of quartzite from Montebello.

Among accessory constituents may be mentioned some muscovite and graphite, both visible with the magnifying glass, grains of a triclinic feldspar, small quantities of carbonates, probably rich in iron judging from their brown colour, isolated plates of biotite and titanite in rounded grains and elliptical sections.

Accessory constituents.

The granular limestone of the Montebello section is rather coarse in grain, of a dirty grey-green colour and characterized by a considerable content of chlorite. It also contains microscopically some quartz and feldspar, in part microcline.

Not far from Montebello, at a place called Lefaivre, an opening was made a short time ago in granular limestone in the search for graphite. The limestone is here snow-white, much more coarse-grained (grains up to 1 cm.) and contains light brown mica, some muscovite and rounded plates of graphite (up to 2 mm. diameter).

Different type of gneiss.

A type of gneiss entirely different from that already described I found north and north-west of Lachute station (76 miles east of Ottawa). Between Lachute, Lakefield, and the mass of syenite which covers a part of Grenville and Chatham Townships (see geol. map accompanying Annual Report Geol. Surv. Can., vol. VIII., N.S.) this gneiss appears to cover a considerable area. Hand specimens were taken from a number of points and were found to correspond with one another macroscopically as well as microscopically.

Microscopic description.

The uniformly medium-grained rock shows on the cross-fracture a typical stratified structure occasioned by reddish layers composed mainly of potash feldspar and some quartz, alternating with layers rich in hornblende and mica. In other specimens this alternation is more or less indistinct and a granular striped structure appears which passes over one almost completely granular. Under the microscope the rock is seen to be composed essentially of feldspar and hornblende with decreasing quantities of quartz and mica. The hornblende is green and transparent and exhibits in sections parallel to the prism zone a maximum extinction angle $\mathfrak{C} : \mathfrak{C}$, 18–20°. Absorption and pleochroism are strong; $\mathfrak{A}$ is light greenish-yellow, $\mathfrak{B}$ and $\mathfrak{C}$ approximately equally dark grass-green. The outline is in general irregular, but many grains are much elongated in the direction of the $\mathfrak{C}$ axis and sometimes rough crystal outlines are observed corresponding, not only to faces of the prism zone but also to terminal faces. The much more rarely occurring brown mica sometimes exhibits six-sided outlines. The allotriomorphic feldspar is to a small extent plagioclase but chiefly orthoclase and microcline. Extremely common and very various in appearance are the microperthitic intergrowths. The orthoclase contains spindle-shaped inclusions or irregular patches of a feldspar characterized by a higher refractive index and double refraction. Further the orthoclase grains are sometimes peripherally surrounded by a narrow edging of more strongly double-refracting feldspar substance which is certainly of later growth. Apatite and zircon occur as accessory constituents in relatively large quantities.

Structure similar to a plutonic rock.

The microscopic structure of the gneiss reminds one strongly of that of a plutonic rock. This impression is produced particularly by the tendency in the amphibole and mica to regular outlines, their frequent

bunchy aggregation and the difference in age of these two minerals as compared with that of the feldspar and quartz. On the other hand the ragged development and frequent intergrowth and interpenetration of the contituents so common in other gneisses is entirely wanting. At any rate one may express with great probability the supposition that this Lachute gneiss is of eruptive origin and this is supported by an analysis made by Dr. Dittrich which gave :—

Probably of eruptive origin.

	I.	II.
SiO_2	59·89	67·19
TiO_2	0·96	0·81
Al_2O_3	17·70	11·68
Fe_2O_3	1·95	4·17
FeO	2·71	
MgO	1·56	2·63
CaO	2·53	3·04
Na_2O	5·74	6·23
K_2O	5·83	4·17
P_2O_5	0·17	0·08
H_2O	0·29	
CO_2	0·39	
	99·72	

Under II the corresponding molecular percentages are given, neglecting the water and CO_2 and calculating all iron as FeO. One is struck upon first glance by the distinct difference between this and the Montebello gneiss, although both analyses show almost the same content of silica and alumina. The soda and lime are however quite different. The whole composition of this Lachute gneiss corresponds with that of an eruptive rock, and for it may be given :[2]—

S	A	C	F	a	c	f	n
68·00	10·40	1·28	8·56	10·5	1	8·5	6

This formula fits in very well with those of syenites rich in alkali between the types Umptekite and Hedrumite. There is a remarkable similarity between its composition and that, for example, of the syenite from Red Hill, New Hampshire, (Analysis III) in molecular proportions.

Difference between Montebello and Lachute gneiss.

	III.
SiO_2	66·24
TiO_2	0·68
Al_2O_3	12·00
FeO	4·79
MnO	0·03
MgO	1·76
CaO	2·89
Na_2O	7·64
K_2O	3·83

The high value of Na_2O can here be explained only by microscopic and perhaps also cryptoperthitic intergrowth of orthoclase with a soda feldspar. The average plagioclase has a composition $Ab_4\ An_1$, and is therefore an acidic oligoclase; probably there are present in the rock albite and a basic oligoclase.

Eruptive gneiss from Trembling mountain and Lakefield, P. Q.

Adams, in the investigation above mentioned, gives the analysis of an eruptive gneiss from Trembling mountain. This rock is more acidic to the extent of about 10 per cent of SiO_2, and corresponds in its composition to a granite. At a place called Lakefield, Argenteuil Co., P.Q., a gneiss was collected that does not differ essentially from the one just described. It is decidedly more fine-grained, and contains "Augen" of feldspar, 0·5—1 cm. diameter, whereby the structure is rendered somewhat more "flaserig." The cleavage surfaces of these feldspars are much bent, sometimes are quite crushed. Cleavage plates parallel to oP are in some cases without twinning striæ, and as far as their strong undulose extinction will allow of a determination the extinction is parallel. Other cleavage faces exhibit the cross-hatching of microcline. Under the microscope the grain is seen to be distinctly coarser than that of the gneiss from Lachute. The principal part of the section is made up of a mosaic of little feldspar grains, of which the striated and not striated are present in about equal parts. Quartz is present in much smaller quantity than the feldspar; its quantity may easily be overestimated, as many grains, which on account of their great clearness and high double refraction appear to be quartz, are found upon higher magnification to be covered with fine twinning striæ. This aggregate of colourless grains in large spots shows a quite irregular structure; in other places a parallel structure is clearly seen, all grains being elongated in one direction and arranged parallel to one another. The outlines of the grains are not lenticular but approximately rectangular, resulting in a layer structure.

Microscopic section.

Dark constituents.

The dark constituents are green hornblende, pyroxene, some garnet and ores; mica is apparently entirely absent. These constituents are always aggregated together in narrow bands. The hornblende is apparently the same as in the syenite gneiss. The pyroxene is in part rhombic, as is evidenced by the weak but distinct pleochroism, parallel extinction, lower interference colours, &c. Along with it, and in smaller quantities, there occurs a light greenish-gray monoclinic augite, with scarcely perceptible pleochroism. While the hornblende is always irregularly bounded, the pyroxenes, especially the rhombic ones, are in the form of columnar crystals, sometimes with rounded ends. The garnet is rare; it is transparent, of a very light-red

colour, is completely isotropic, and shows rounded or ragged forms; it is always filled with vermiform inclusions of the light-coloured constituents. Frequently a garnet grain will have at its centre an opaque metallic particle, the vermiform inclusions radiating from this. Any regular arrangement of the other constituents around the garnet is not observable. This gneiss also is probably of eruptive origin, and possibly is connected in some way with the neighbouring anorthosites, which in part carry garnet.

Gneiss cut by dyke.

Near the house of Rev. Mr. Pierce this gneiss is cut by a dyke about 0·5 metre thick of a black rock rich in mica. Examined microscopically, it is found to contain a good deal of reddish-brown mica, almost colourless pyroxene in narrow columnar crystals, and serpentine pseudomorphs after olivine. The interspersed mass is too much decomposed to be determined more exactly. In all probability it is a lamprophyre dyke-rock belonging to the Minette-Kersantite class.

Certain other gneisses will be mentioned in the description of the occurrences of apatite and graphite.

On the Occurrence of Apatite and Mica north of Ottawa

First discovery of apatite.

Apatite in large deposits of economic value was known in the district of the Lièvre river as early as 1829, but was soon forgotten. In the year 1847, Dr. Sterry Hunt[3] described similar occurrences in the province of Ontario, between Kingston and Ottawa, in the counties of North and South Burgess, Lanark, Frontenac, Renfrew, Addington and Leeds. A regular exploitation was begun in the sixties and was carried on till the beginning of the nineties. At this time the Canadian apatite industry succumbed to the enormous development of the phosphorite industry in Florida, Alabama and neighbouring states. It was mainly in the two districts indicated, one north of the Ottawa river in the province of Quebec, and one south of the river in Ontario, that the mines were situated. The observations here recorded refer to the first of these districts, and the principal mines on the Lièvre and in the neighbourhood of the Gatineau river were the only ones visited.

Area of apatite bearing rocks in province of Quebec.

The area in which apatite occurs and is mined, extends over a large part of the townships of Buckingham, Portland East, Portland West, Templeton, Wakefield, Bowman and neighbouring townships. From the copious literature upon this subject, it may be said that it was very early recognized that the apatite was generally associated with rocks which were entirely or for the most part composed of pyroxene,

and which Sterry Hunt[5] called 'pyroxenite.' Concerning the origin of this 'pyroxenite' and of the apatite, opinion is still very much divided.

Sterry Hunt on mode of occurrence.

Sterry Hunt[4] described in the year 1863 the apatite as occurring in the Laurentian rocks, both distributed in crystals through carbonate of lime and in 'irregular beds running with the stratification and composed of nearly pure crystalline phosphate of lime.' In North Burgess the mineral occurs in 'several parallel beds interstratified with the gneiss.'

In the year 1866, the same author says[5], 'the presence of apatite seemed characteristic of the interstratified pyroxenic rocks, the apatite marks the stratification.' Simultaneously, 'true apatite vein-stones cutting the bedded rocks of the country' were mentioned. These were 'well-defined veins traversing vertically and nearly at right angles the various rocks.' In the year 1884, Hunt[6] says: 'I have within the past few months examined with some detail many of the apatite workings in Ontario, which have served to confirm the early observations and to give additional importance to the fact that the deposits of apatite are in part bedded or interstratified in the pyroxenic rock of the region, and in part true veins of posterior origin. . . . . The bedded deposits of apatite which are found running and dipping with these (above mentioned gneisses, quartzites, limestones and "pyroxenite layers,") I am disposed to look upon as true beds deposited at the same time with the inclosing rocks. The veins, on the contrary, cut across all these strata, and in some noticeable instances include broken angular masses of the inclosing rocks.' Further, 'in rare cases what appear from their structure and composition to be veins are found coinciding in dip and strike with the inclosing strata.'

Early observations confirmed.

In the year 1885, after another visit to the apatite mines in the Lièvre district, the same author remarks[7]: 'The large mining operations lately undertaken in the Lièvre district show that the crystalline phosphate of lime or apatite belongs to lodes of great size which traverse the ancient gneiss of the region. These lodes include a granitoid feldspathic rock and a pyroxenic rock with large masses of quartz, of carbonate of lime, of pyrites and of apatite. All of these often show a banded structure not unlike that of the gneiss to which they are evidently posterior and of which they often contain fragments.'

J. W. Dawson on mode of occurrence.

J. W. Dawson, in 1876, says[8]: 'It appears from the careful stratigraphical exploration of the Canadian Survey in the districts of Burgess and Ainsley, which are especially rich in apatite, that the mineral

occurs largely in beds interstratified with the other members of the series, though deposits of the nature of veins likewise occur. It also appears that the principal beds are confined to certain horizons in the upper part of the Lower Laurentian, above the limestones containing Eozoon, though some less important deposits occur in lower positions.'

Veins a secondary formation.

Further, he says of the veins: 'Since these veins are found principally in the same members of the series in which the beds occur, it is a fair inference that the former are a secondary formation, dependent on the original deposition of apatite in the latter, which must belong to the time when the gneisses and limestones were laid down as sediments and organic accumulations.' Dawson further points out that in the Primordial time animals 'with phosphatic crusts and skeletons' predominated, and the calcium fluoride, contained in the apatite, also occurs in bones especially in many fossils. He lays especial value upon the fact of the occurrence of phosphorite nodules in Cambrian and Silurian strata along the St. Lawrence river and south of the Ottawa river, and which Sterry Hunt, in the Geology of Canada, considered to be coprolites.

Harrington quoted.

Harrington, in 1878, says[9]: 'That many of the apatite deposits of this region (Templeton) are not beds, is plainly shown by the manner in which they cut across the strike of the rocks containing them.' He further mentions the opinion of Brögger and Reusch as to the eruptive origin of the apatite veins of Southern Norway, and remarks: 'This idea of an igneous origin cannot be adopted for our veins,' points out the fact that the 'pyroxenite' often contains grains of apatite, and adds 'no doubt they are the strata from which the apatite of the veins has been chiefly derived.'

J. F. Torrence on occurrence of deposits in Portland and Buckingham.

In 1883, J. F. Torrence[10] expresses the opinion that the apatite deposits of Portland and Buckingham are irregular segregations from the country rock, and that these belong to one or more rock zones more or less strongly impregnated with apatite which follow a N.N.W. direction along the course of the Lièvre river. He further remarks: 'During the past season I often noticed in the same pit, patches of apatite that might easily be taken for the contents of a fissure vein, if there were any casing rock on either side of it to separate it from the country rock, and patches of flat-lying apatite that might easily be called bedded, if they were of any great extent or approximately uniform thickness and if the country rock showed any planes of bedding parallel to the longest ones of such patches; or else it might easily be assumed that the country rock had been more or less tilted and overturned since the deposition of the apatite and that the vertical patches

were interbedded and the horizontal ones were veins, if their relations to the country rock were such as veins and beds respectively are wont to maintain, but unfortunately I failed to perceive these conditions.' Further: 'In by far the greatest number of cases the containing rock of apatite is pyroxenite; the veins are very irregular, consisting of large bunches or pockets of ore, yielding hundreds of tons, which suddenly pinch out, but soon reappear when followed on their course.'

Other opinions on mode of occurrence.

In 1885, W. B. Dawkins[11] expresses the opinion that apatite occurs 'in veins'. 'They occur in bright crystalline massive schists composed of pyroxene, mica, orthoclase, triclinic feldspar, and apatite, which if not bedded would pass for an eruptive rock'; further, that these accompanying rocks as well as the veins themselves have obtained their material 'from some common deep-seated source of hydrothermal action.'

In the same year, Kinahan says[12]: 'It is possible the present Canadian apatites were originally limestones or allied rocks, the change to apatite being due to paramorphosis, which at present cannot be satisfactorily explained.'

Moreover, in 1884, G. M. Dawson[13] and F. T. Falding[14] are of the opinion that the 'bedded apatite' is of organic origin and that the Laurentian strata in which they occur are altered sediments. The 'vein apatite' has been formed from this by a 'process of segregation.'

On the other hand, in 1886, R. Bell[15] says that the apatite comes principally out of the pyroxenite and there are no indications of organic origin. The pyroxenite is possibly 'derived from igneous sources.'

Supposed clear evidence of eruptive origin.

E. Coste[16], in 1887, attributes the formation of apatite and a part of the iron ores occurring in the Laurentian to eruptive agencies. He says: 'We believe that we have gathered year after year strong and clear evidence to show that our deposits of iron ores in the Archæan rocks are of an eruptive or igneous origin, but also that our deposits of phosphate are exactly similar and have also the same origin.' Further, 'in the region north of Kingston, in the counties of Frontenac, Leeds, Lanark, Renfrew, Pontiac, and Ottawa many deposits of iron ores and many deposits of phosphate were observed also in the same association with igneous rocks, and both cutting through the Archæan rocks. In the case of the phosphate the igneous rock was often the rock termed by Dr. Hunt "pyroxenite," but at other times it was a pegmatite or a mica syenite or a pyroxene syenite.' He further points out that in many localities the iron ores and the apatite occur in the same veins,

thus at the Blessington mine in nine different pits; in the summer of 1886, 500–600 tons of iron ore and 1,500 tons of apatite were obtained. 'We should conclude that the iron ores and phosphate to be found in our Archæan rocks are the result of emanations which have accompanied or immediately followed the intrusions through these rocks of many varied kinds of igneous rocks which are no doubt the equivalent of the volcanic rocks of to-day.'

Penrose (1888)[17] verified the frequent vein nature of the apatite deposits. Concerning the 'pyroxenites' he says: 'The pyroxenic rock is never found distinctly bedded, though occasionally a series of parallel lines can be traced through it which, while possibly the remains of stratification are probably often joint planes.' Further, 'the gneiss in some places has no distinct line of separation from the pyroxene but seems to have been impregnated with some of it, forming for a few feet from the line of contact a more or less pyroxenic gneiss.' With respect to the origin of the apatite, Penrose does not give any definite opinion. Penrose quoted.

A. R. C. Selwyn[18] in 1889 says: 'There is absolutely no evidence whatever of the organic origin of apatite or that the deposits have resulted from ordinary mechanical sedimentation processes; they are clearly connected for the most part with the basic eruptions of Archean date.'

W. B. M. Davidson[19] remarks in 1892: 'The pockets of apatite occur in bands or beds of pyroxene of varying thickness, but considerable regularity and which are conformable with the bedding of the gneiss. Most of the ablest Canadian geologists agree that these strata were deposited conformably in the pre-palæozoic sea and that they have been subjected to heat and pressure which has metamorphised the primitive character of the rock. Some writers, however, have considered the pyroxene to constitute lodes or dikes in which the apatite occurs as an accessory mineral, filling the crevices by plutonic action and hence of eruptive origin, which I take to mean that they think the apatite came to its present position through sublimation or through intrusion in a molten state. I am certainly of opinion that this theory is far stretched and without scientific corroboration.' Then he says: 'I believe that the phosphate was more or less regularly deposited in the varying beds in the Laurentian sea and that afterwards during the time of metamorphism phosphate of lime and other minerals crystallized out of the mother-rock in the most convenient positions that they could find. W. B. M. Davidson's views on origin.

R. W. Ells quoted.

R. W. Ells[20], who in recent years has examined for the Geological Survey that part of the province of Quebec which contains the apatite deposits along the Lièvre river, comes to the conclusion that the pyroxenites are of eruptive origin and that the occurrence of the apatite is essentially connected with the boundary of the pyroxenite and the gneiss. In connection with this he says: 'From many analyses we know that all pyroxenes contain a very considerable amount of calcium ranging from twenty to nearly thirty per cent. Since then the pyroxene in its intrusion with the gneiss must have ascended along lines of fracture or least resistance, it would be reasonable to infer that vapours charged with phosphoric acid ascended along such lines rather than through the mass of the dike and that in certain positions in proximity to the margins of the dike, these vapours impregnated the softened or heated mass from which as a result of chemical action upon the calcareous portion the phosphate of lime was produced. The mineral would therefore appear to owe its origin to chemical agency rather than to organic.'

Origin due to chemical agency rather than organic.

Rocks from apatite regions examined by Adams.

In closing this reference to the literature of the subject an investigation by Adams[21] must be noticed, which deals with rocks from the apatite region of Quebec and which therefore is of interest. Starting out from the spotted gabbro of Norway as apatite-bearing, Adams has examined certain pyroxenites with respect to their containing scapolite. The specimens came from Lot 35, Range V., of Portland West, from the McLaurin mine, Templeton, and the Emerald mine. In none of these was scapolite found. Further, two rocks collected by E. Coste at the Star Hill mine, Portland West, and the Blessington mine, Ont., were recognized as granular eruptive rocks and designated as mica syenite and augite mica syenite. On the other hand, Adams found in a series of rocks from Arnprior on the Ottawa river, a rock consisting essentially of pyroxene, hornblende and scapolite and which he called scapolite diorite on account of its granular structure. Similarly in the Museum of the Geological Survey there were some scapolite-bearing rocks from Ontario, designated as plagioclase scapolite diorite and plagioclase scapolite amphibolite. Apparently these occurrences, as Adams remarks, are not connected with the apatite deposits. Lacroix later examined the same rock from Arnprior[22].

Diverse opinions held.

Unfortunately I have been unable to consult the greater part of the Canadian literature, but it is evident from what has been quoted above that the views with regard to the Canadian apatite are very diverse.

Davidson and perhaps a few other geologists deny the occurrence of apatite and pyroxenite in true veins. According to them the pyroxe-

nite is of the same age as the gneiss and stratified conformably with it. The apatite has been derived from an original phosphoric acid content of the Laurentian deposits; by their metamorphosis it crystallized out from the 'plastic magma.'

Apatite beds and veins cut the gneiss.

The greater number of Canadian geologists are agreed, however, that both 'beds' and veins of apatite occur, which cut the gneiss strata in all possible directions. They regard the former as derived from phosphoric acid in the rocks due to organic remains, the veins being formed from a leaching out of this material, *i.e.* by lateral secretion. In connection with the organic origin of the phosphoric acid much weight is laid upon the occurrence of graphite in the neighbourhood of the apatite and also [the graphite veins in the neighbourhood of Buckingham on the Lièvre river contain green apatite in compact masses], on the occurrence of Eozoon Canadense in the Laurentian limestones, and of certain iron ores in the Laurentian, the origin of which is also supposed to be connected with the action of organisms.

Genetic relation of apatite and pyroxenite.

Selwyn, Costé, Ells, and also Bell, bring the formation of apatite into genetic relation with that of basic eruptive rocks (*e.g.* pyroxenite). Ells speaks directly of a fumarole action which accompanied or followed their formation and through the action of which upon the lime of the pyroxene the apatite was formed. This view is very similar to the theory put forward by Brögger and Vogt to explain the formation of the apatite veins of southern Norway.

Occurrences now difficult to study.

Unfortunately the opportunities for the study of the occurrences of apatite are very much less advantageous than they were at the time when the industry was in a flourishing condition. Most of the mines are under water and are inaccessible so that one is in many cases confined entirely to the material in the dumps. Further, most of the works are in thick woods, through which it is difficult to travel and in which exposures are rare. Certain favourable opportunities are found where mica occurs in the neighbourhood of the apatite in quantity and quality, sufficient to justify mining operations which are now being carried on. Such a locality is the Vavasour mine, which on account of the very useful opportunities it offers for certain conclusions, will be described somewhat in detail.

Vavasour mine.

The Vavasour mine is situated about 14 miles from Ottawa. It is an old mine which was originally worked for apatite, but at present only for mica (phlogopite.) Both minerals here occur in the same veins and owe their formation undoubtedly to the same process. A

number of veins were being worked, which, with a steep dip and a strike almost N. and S., are all so near one another that the whole mine occupies but a very small area. The principal vein has been opened up by cuttings to a length of about 700 feet and in places to a depth of about 50 feet.

Geological relations.

The best insight into the geological relations is obtained at an opening at the south-east side of the mine property. Here there is a partially exhausted and now abandoned cutting in the gneiss. The gneiss consists of light and dark layers, the former consisting in part of red orthoclase with very much bent cleavage faces and much quartz. In the darker layers the magnifying glass reveals much biotite, some hornblende and quite sporadically a grain of red garnet. The strike of the gneiss is N. and S., the dip 30° W. The apatite vein partially exposed by quarrying has the same strike, but dips, steeply to the east so that the dip of the gneiss layers and of the apatite vein are almost perpendicular to one another. The thickness of the vein is about 1 m. Its borders show up quite sharply against the country rock; in the gneiss no alterations due to contact were observed. At the bottom of the exhausted cutting and on remaining fragments of the border of the vein one sees that directly upon the border plane pyroxene crystals have formed, prismatically developed up to 5 cm. thick and twice as long. The prism zone is almost perpendicular to the plane of contact. A second vein mineral is reddish-brown phlogopite, also usually well crystallized, but sometimes in scaly aggregates filling out the spaces between the pyroxenes. Everywhere one can discern that the pyroxene is the earlier formed and the phlogopite the later formed mineral. In places the two build a regular net-work the interspaces of which are either empty or filled with a coarse-grained aggregate of reddish-coloured calcite. The central main mass of the vein consists of the same calcite and of green apatite, the relative quantities of the two vary, the former generally predominating. The apatite either exhibits the crystalline form $\infty P \left\{10\bar{1}0\right\} P \left\{10\bar{1}1\right\}$ with rounded edges and corners, or forms large irregular lumps. The richer the vein is in calcite, the better is the apatite crystallized. Calcite crystals are entirely absent. The sequence of the four vein minerals here is therefore: pyroxene, phlogopite, apatite, calcite. The same relations appear on the opposite edge, the vein is laterally symmetrical.

Vein minerals

From this vein a narrow vein branches off into the gneiss having a thickness of about 0·5 m. Its edges are also perfectly sharply defined against the gneiss. The vein is symmetrically formed

and consists as the accompanying figure shows of two lateral zones *a* and *b* almost equal in thickness and of a central part *c* about 25 cm. thick ; *g* is the gneiss. The two lateral zones consist of a very uniformly granular mixture of pyroxene, phlogopite and apatite. The size of the grains is about 1—2 mm. Pyroxene and mica are present in about equal quantities ; apatite is shown under the microscope to be decidedly less in quantity. Evidently it is a mineral aggregate of similar origin to that of the lateral portions of the main vein, only the minerals have been simultaneously and more quickly formed. The central portion consists of coarsely crystalline almost pure reddish and greenish apatite.

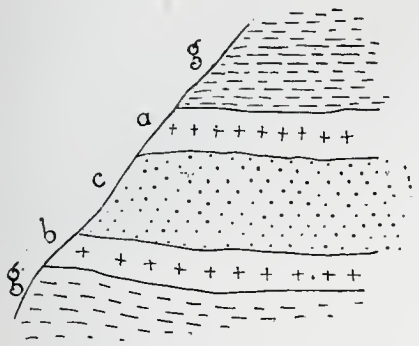


FIG. 1.

Description of two lateral zones.

In other parts of the property the apatite-bearing veins do not cut gneiss, but pieces of country rock collected from the dump and also directly from the mine are found to be typical scapolite gabbro. In the case of medium and coarse-grained varieties, it is a rock of typically massive structure and consists of about equal quantities of pyroxene—partially uralitic—and of scapolite. Upon a first glance it is seen to be a basic plutonic rock, and distinctly different from the gneiss. Along with the irregular granular structure there is a streaky structure in many blocks, as is of very frequent occurrence in gabbros. (The petrographical description of these rocks will be given later.) On account of the very few exposures and the short time spent in the district, nothing further can be said with respect to the distribution of the gabbro. It certainly seems to be of no very great extent. It could not be determined whether it formed a little stock or a vein.

Basic plutonic rock.

The vein consists essentially, as was described above, of the peripheral portions made up of pyroxene and phlogopite, and the central part consisting of apatite and calcite. Mining operations are confined to those portions in which the pyroxene is in smaller quantity and the phlogopite occurs in plates up to a square foot in size, and sometimes in thick crystals.

From the relations observed in the Vavasour mine it may be concluded that :

1. The apatite here occurs in true veins. That together with other minerals it fills fissures which cut through the gneiss and through a plutonic

Apatite occurs in true veins.

Similar relations at MacRaemine.

rock belonging to the family of the gabbros and that it exhibits with respect to the gneiss an intrusive character. This fact has been observed also in many other places as is evident from the literature quoted above. Ells mentions the same relations as occurring at the MacRae mine in Templeton township, at the Little Rapids mine, and says further 'At Crown Hill (mine) the great masses of pyroxene have thrown the gneiss entirely out of its normal strike.' Harrington says: 'As examples of this may be mentioned an important vein on the seventh lot of the first range of Portland, the course of which is N. 15° W., while the strike of the country rock is N. 45° W. On the nineteenth lot of the ninth range of Templeton the rocks strike N. 40° E. and are traversed nearly at right angles to their strike by a vein of apatite. Again on lot fifteen of the eighth range of Templeton are three veins, whose courses are respectively N. 40° W., N. 60° W., and N. 67° W., while that of the county rock is N. 20° W. In some instances deposits which look like interstratified beds in place are here and there seen to give off lateral branches which cut directly across the strike of these rocks. An example of this was noticed at Mud Bay on the twelfth lot of the eleventh range of Templeton, in the case of an apatite vein occurring in garnetiferous gneiss.'

London and Emerald mines.

I myself have observed similar relations in a number of different mines. Above the London mine the garnetiferous gneiss is cut by a large number of pyroxenite veins with very different strikes, forming in fact in some places a perfect net-work. In the lower opening of the London mine the gneiss may be very clearly seen thrown out of its normal position along the apatite vein and bent over nearly at right angles. Here, as Ells pointed out above, in connection with the formation of the cracks there seems to have taken place no inconsiderable disturbance of the position of the gneiss. The fact that the pyroxenite veins cut through the gneiss almost at right angles is also, in the North Star mine, very plainly visible. At the Emerald mine, as will be pointed out later, gneiss and gabbro are cut by pegmatite veins, and these last in their turn undoubtedly by apatite veins.

That similar conditions exist in the apatite region, not visited by me, south of the Ottawa river in Ontario is seen by a profile, given by Penrose, of the Foster mine, Frontenac county. Here also we have cases of apatite veins having dips almost at right angles to that of the gneiss.

Apatite veins always accompanied with pyroxenite.

2. At the Vavasour mine the apatite veins occur along with a scapolitised gabbro. As many authors have stated and as I was also able to prove without exception, the apatite veins are always accom-

panied by so called 'pyroxenite'; they seem to be connected with its ocurrence, and the first question seems to be as to what these 'pyroxenites' are.

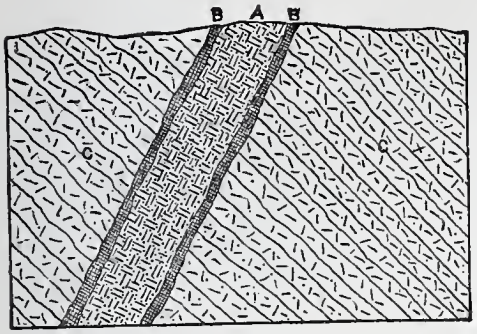


FIG. 2.—Section of one of the north-west and north-east veins at Foster's Mine, Loughboro', Frontenac county, Ont., ; A, apatite; B, pyroxene: C, country gneiss. Scale--1 inch = 7 feet.

Pyroxenites of plutonic origin.

A portion of them are doubtless intrusive rocks of plutonic origin and belong to the family of the gabbros, norites, diorites, and, in part, to the basic syenites and shonkinites. Adams (see above) has examined two such rocks and designated them as mica syenite and pyroxene mica syenite. In certain cases the rocks exposed in the mines are fresh; generally, however, they are much altered, whereby particularly a new formation of scapolite, at the expense of the feldspar, has taken place. Such scapolite gabbros and related rocks I have collected and examined microscopically from the Vavasour, London, Emerald, North Star, Union, High Rock and Crown Hill mines, and from the Poupore post-office, in short, from almost all the apatite localities visited, They form an analogue to the scapolite gabbro of southern Norway, with which also the occurrence of apatite veins is connected. A conversion of pyroxene into brown hornblende, as is the case in the so-called spotted gabbro from Oedegården, has not been met with to my knowledge. The pyroxenes are partly altered to green uralite, but the change seems to be independent of the formation of the apatite veins.

Scapolite gabbros examined microscopically.

Mineral aggregates.

Another portion of the 'pyroxenite' has formed in the cracks themselves, and constitutes mineral aggregates, which, in general, are of the same age as the apatite. Such a uniformly granular aggregate of pyroxene, phlogopite and apatite was mentioned in connection with the small vein at the Vavasour mine. The composition and structure of these masses is very varied. In some cases they can be distinguished from the unaltered plutonic rock at a first glance; in other cases they are extraordinarily like these, not only macroscopically, but also microscopically, being rich in scapolite, &c., so that a dividing line between the two classes of 'pyroxenite' can hardly be drawn. This, in the nature of the case, is not surprising. As examples, two cases from the Emerald mine may here be mentioned. In the neighbourhood of the Belleau pit, and underneath the smithy, on the

Pegmatite cut by apatite veins.

boundary of the Squawhill mine, the gabbro, which forms the main mass of the whole hill, is intersected by pegmatite veins, which are widely distributed throughout the whole region. They are granite pegmatites, consisting essentially of quartz and microcline. At both places the pegmatite is cut by narrow apatite veins, which exhibit a symmetrical structure, as in the accompanying figure. The two outer zones about 10-12 cm. thick, sharply defined against the pegmatite, consist of such 'pyroxenite.' The central zone, about 30-40 cm. thick, consists of calcite and apatite. The dividing lines between the 'pyroxenite' and the central zone are not sharp; many crystals of pyroxene, very well formed, penetrate into the calcite, and in some places a gradual transition is found, caused by increase of calcite and decrease of pyroxene. The main part of the 'pyroxenite' is, however, a uniform, rather coarse-grained mineral aggregate, which, under the microscope, is found to consist essentially of augite and scapolite, and is hardly to be distinguished from many altered plutonic rocks. Very beautiful examples of such 'pyroxenite' selvages may be observed in the small opening near the Poupore post-office. The rocks rounded by glacial action show various gneisses, some very rich in garnet, interlaminated with quartzite and cut by a scapolitised gabbro, which contains apatite in lumps and veins. The gneiss also is cut by numerous fissures, often dwindling away to nothing, and each of these is edged with a zone, as thick as one or two fingers, of 'pyroxenite,' consisting of individuals of augite set perpendicular to the edge of the vein. The same pyroxenite zones are seen in the figure on page 21, showing the apatite vein of the Foxton mine, according to Penrose.

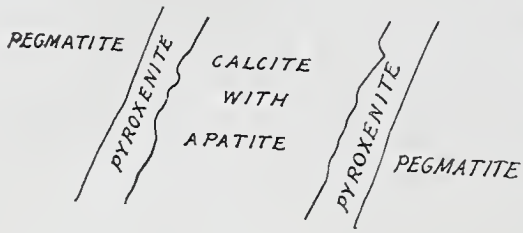


Fig. 3.

Fine examples of pyroxenite at Poupore post office.

From what is said above, it follows that the masses, designated by the general name of 'pyroxenite,' are genetically very different. Whereas in petrography one understands by the name pyroxenite a primary plutonic rock consisting almost exclusively of members of the augite family, we have here to deal mainly with altered gabbros and secondary vein fillings, which are connected with the formation of the apatite.

3. At the Vavasour mine there are essentially four minerals (see Plate I) which constitute the vein material, pyroxene, phlogopite, apa-

tite and calcite, and this order gives their relative time of formation. The pyroxene was the first formed and the calcite the last. This also obtains in the main for the other mines examined by me, although one or other of these minerals is sometimes present in comparatively small quantity or entirely absent. Thus in the dumps of the Cascade mine, I found only traces of apatite, the workings being carried on for mica; in the veins, cutting the diorite gabbro at South March, the pyroxene seems to be absent. The general character of the dikes, however, is so similar that they must surely have the same origin. In many occurrences feldspars play an important part, particularly a gray microcline, which covers whole walls. I have seen nothing of the large quartz masses which many authors mention. Quartz occurs only unimportantly. There are in addition a large number of minerals which will be mentioned later.

Pyroxenites of Upper Lièvre river apatite mines.

In the large apatite mines upon the upper Lièvre river, Union, High Rock, Crown Hill, and in part North Star, the above described vein character occurs less distinctly. The 'pyroxenites' here contain irregular lumps and large pockets of mostly pure apatite and phlogopite, while calcite is much more subordinate. From these, for the most part irregularly bounded masses of apatite, there run off veins which are often filled only with thin plates of mica standing perpendicularly to the walls, widening out here and there and then again carrying apatite. The walls of the mine are here and there penetrated by a perfect network of such little veins, or the whole pyroxenite is fairly impregnated with apatite and mica. Here indeed it is very difficult to determine the boundary between altered plutonic rock and later formed pyroxenite. Penrose gives a number of drawings which illustrate these relations very clearly.

Without going into a special description of the individual occurrences, certain important points bearing upon the genesis of these rocks may be indicated.

Age of pyroxenite and apatite in doubt.

As is evident from the literature already quoted, many authors speak of a 'bedded' pyroxenite and apatite and deduce from this the conclusion that they are both of the same age as the Laurentian strata and belong to a certain division of these. I have been unable in any locality to convince myself of this fact. That many veins are developed as bedded veins (Lagergänge), in part filling crevices which in strike and dip correspond with the gneiss, is correct; it is natural that many cracks should be formed in the direction of least resistance. As proof of these deposits being of the same age as the neighbouring gneiss, a certain parallel structure in the pyroxenite and in the apatite masses connected with them has been pointed out, and further the fact that

no sharp line of demarkation exists between these latter and the gneiss, that they pass over one into the other.

Pyroxene rock never distinctly bedded.

As far as the parallel structure is concerned, I concur exactly in the view expressed by Penrose: 'The pyroxene rock is never found distinctly bedded,' &c. A parallel structure at all comparable with that of the gneiss I have never found. That many veins exhibit a laterally symmetrical formation has already been pointed out in connection with the Vavasour mine. A typical example from Mud Bay, Templeton county, as given by Harrington, is here figured. It is a structure which is very well known in the case of ore veins. When such a vein is deposited conformably between gneiss strata its own layers must naturally be parallel with the cleavage planes of the gneiss. Another example from the Grant mine, also by Harrington, exhibits very regular alternations of layers of apatite and pyroxene about $\frac{1}{4}$-inch thick; the structure, as Harrington points out, reminds one strongly of Eozoon. It is expressly stated that the piece comes from a 'vein.' Penrose[17] gives the accompanying sketch of a pit in the neighbourhood of

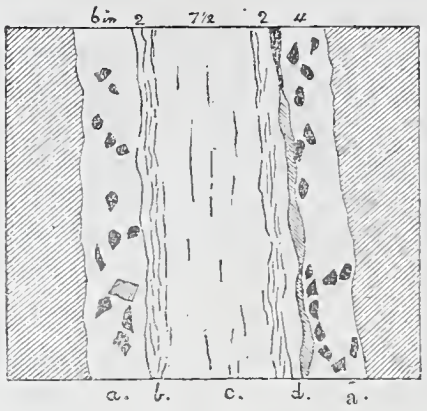


Fig. 4. *a*. Calcite and mica. *b*. Fine grained mica in many lines, with pyroxene and little apatite. *c*. Pyroxene, granular apatite, and a little mica, in fine scales, arranged in wavy lines in the direction of the vein. *d*. Mica-pyroxene and thin layers of apatite, calcite and mica.

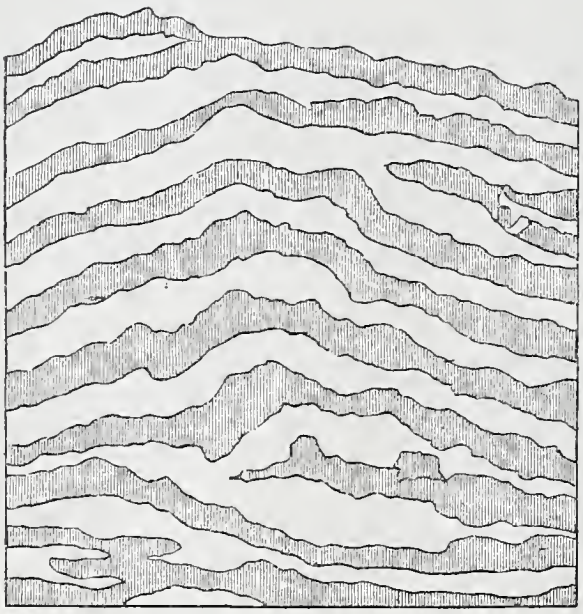


Fig. 5. Veinstone showing alternate layers of apatite and pyroxene.

the Emerald mine. Here evidently there are veins in the pyroxenite which in places dwindle away, and in other places widen out and are

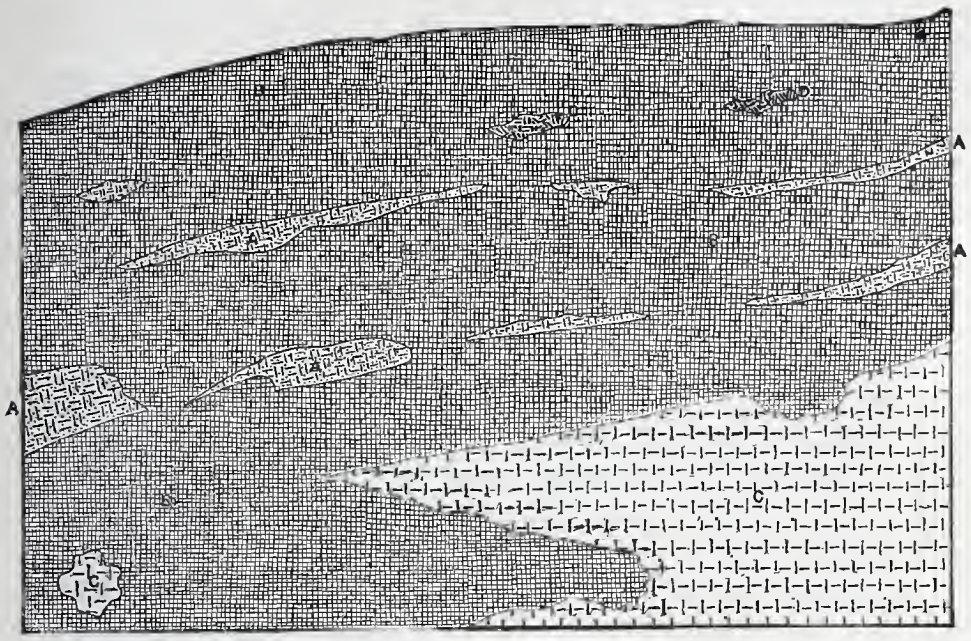


Fig. 6. Section in a pit near the Emerald Mine (looking west), Buckingham, Ottawa County, Quebec. *a*. Apatite ; *b*. Pyroxene : *c*. Feldspar ; *d*. Pyrite. Scale, 1 inch= 6 feet.

filled with apatite, and are probably connected with a large apatite mass which was mined. The parallel direction of these has nothing to do with a stratified or schistose structure. For comparison another figure by Penrose[17] of a locality at Smith's mine, Frontenac county, is given where such parallel apatite veins cut the syenite. In Plate IV. a piece of vein from the Vavasour mine is shown whose structure at first sight strongly reminds one of the streaky structure of 'Augen-gneiss.' From the description on page 19 it follows that it is essentially different from it, however. The quotation from Harrington mentioned on page 20 may be recalled, according to which from such apparent 'beds,' fragments and veins run into the gneiss strata.

Apatite veins cutting syenite.

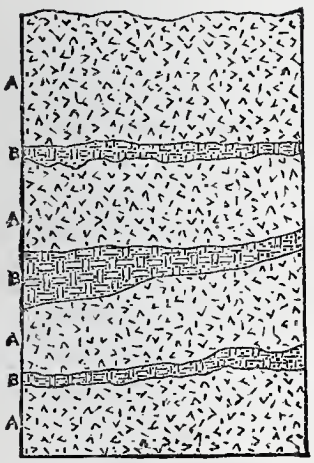


Fig. 7. Opening in west side of a hill near Smith's mine, Oso., Frontenac county, Ont. *a*. Country Syenite ; *b*. Apatite, scale, 1 inch= 24 feet.

With respect to the transition of the pyroxenite into the neighbouring gneiss,

or rather the want of sharp demarcation between the two, the occurrences are very various. At the Vavasour mines there are veins which cut through the gneiss and whose borders are absolutely sharply defined. In other cases, especially where vein formation of the nature of 'pyroxenite' borders on the gneiss, the boundaries are indefinite, and there is an apparent transition. This arises, as Penrose has already pointed out, from impregnation of the gneiss with vein material. Later certain typical examples will be mentioned which leave no doubt that such a process has actually taken place. Plate V shows a vein granite from the London mine upon the spherical planes of jointing of which pyroxene, titanite, pyrite, and apatite have been later deposited. Similar 'leopard granite' is found at Little Rapids and the North Star mine. Plate X fig. II gives the microscopic appearance of a quartzite in which scapolite, pyroxene, apatite, &c. have been deposited in cracks. It is difficult to form an idea as to how far such a process has taken place, as in the mines one sees only that part of the gneiss exposed which was directly in contact with the apatite or the pyroxenite. At the North Star, Union, and High Rock mines, gneisses were collected which were all rich in pyroxene; a very curious gneiss like a granulite and rich in pyroxene, from the London mine, will be described later. How far this content of augite is to be attributed to such secondary impregnation processes can only be determined when these crystalline schists can be followed along their strike to considerable distances from the apatite deposits. In what follows therefore only such cases are introduced as admit of no doubt regarding such a process.

Transition of pyroxenite into gneiss.

Still other facts which point to the vein nature of such apatite deposits, have been mentioned by other authors. Thus, angular fragments of the country rock are found in the veins. On the dump of the Murray pit, Emerald mine, I found fragments of gabbro, as large as one's head, entirely encrusted with apatite. The vein minerals themselves also exhibit occasionally such encrustations. Plate II shows a vein fragment from the Emerald mine; a pyroxene crystal about 3 cm. long and 2 cm. thick is surrounded by a coating of apatite about 3–4 mm. thick, the whole being embedded in coarser crystalline reddish calcite. Structures are thus produced such as are frequently found in ore veins and which are called cocarden structure.

Vein nature of apatite deposits probable.

Further, drusy hollows occur, the walls of which are lined with well crystallized vein minerals. Harrington[9] gives a series of such occurrences and mentions crystals of apatite a foot in length which were collected from such druses. At the Vavasour mine the workmen

showed me a piece of such a druse, the wall of which was lined entirely with little quartz crystals. When Dr. Ells and I were visiting Browns' mine, the owner told us of such a drusy cavity which had been cut into a short time before.

All these peculiarities and the similarity in mineral content of all the deposits of apatite in the province of Quebec known to me, lead to the belief that they are all of the same origin and younger than the associated gneisses. They are accordingly true veins which have been formed in the same way as all other ore veins.

The Vein Minerals.

Vein minerals.

The minerals forming the principal part of the vein filling are pyroxene, mica (phlogopite), apatite, calcite, and some feldspar. Of less importance are amphibole (actinolite), tourmaline, scapolite, titanite, and various metallic sulphides. Further, Harrington gives a long list of other minerals, i.e. fluorspar, quartz, garnet, epidote, idocrase, zirkon, prehnite, cabazite, molybdenite, graphite, &c., of which I only observed a few during my very short visit. Harrington has described all these minerals very thoroughly, and they may therefore here be passed over in a few words.

Pyroxene is the mineral which accompanies the apatite most regularly and in greatest quantity. I saw only one apatite locality in which it seemed to be absent, at least Dr. Ells and I failed to find it, although we made a special search for it. Here there were a series of small veins running through the diorite, near the railway station at South March, not far from Ottawa. An opening was made for the purpose of mining mica, but was soon abandoned as the mica was not very fresh, in consequence of which it had lost its elasticity. In these veins only mica, apatite and calcite were present.

Crystallized pyroxene in apatite veins.

The pyroxene occurs in the apatite veins, partly well crystallized, and partly massive as in the 'pyroxenite.' Here only the former will be dealt with. The crystals are found principally in such deposits as may be said to be typically veins, and which contain much calcite. These veins best exhibit the order of age as given in connection with the Vavasour mine; pyroxene mica, and apatite are the best developed and, being the oldest, are found directly on the border of the vein (the contact). The crystals are usually dark green; the surface is rough and dull; the faces, especially the terminal ones, often appearing as though coroded. On planes of fracture they look very like dark green bottle glass. Almost without exception, they exhibit a very perfect

cleavage parallel to oP, in which direction the crystals generally break on being struck. Crystals which I collected at the Cascade mine are about 6 cm. thick and 9–10 cm. long. They exhibit the forms $\infty P \{110\}$ $\infty P\bar{\infty} \{010\}$ $\infty P\breve{\infty} \{100\}$ $+P \{\bar{1}11\}$ $+P\breve{\infty} \{\bar{1}01\}$ $-P \{111\}$ and $oP \{001\}$ as in fig. 8.

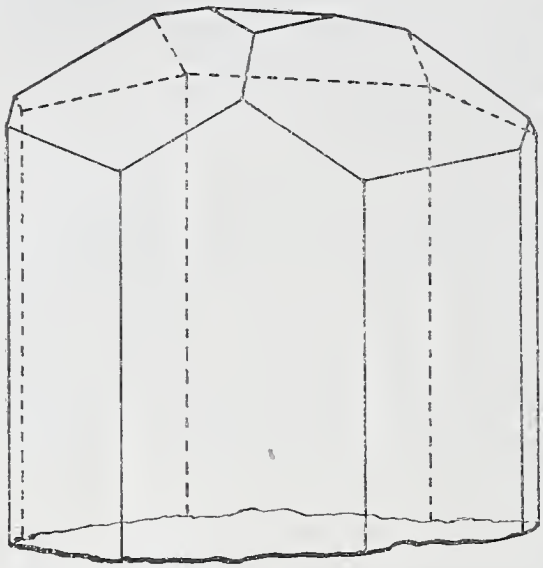


Fig. 8. Pyroxene crystal from the Cascade mine.

Sometimes $+2P \{\bar{2}21\}$ is also present. The clinopinacoid is always very narrow; the other faces of the prism zone about equally developed, or $\infty P\breve{\infty}$ predominating. At the Emerald mine, there occur also almost black crystals perfectly developed and embedded in calcite. Harrington[9] mentions also very light coloured grayish-white pyroxene.

Analysis of grey pyroxene from Templeton township.

The analysis of a variety of grey pyroxene from Templeton township gave, according to Harrington, the composition:

	I.	II.
SiO_2	50·87	48·24
Al_2O_3	4·57	2·55
Fe_2O_3	0·97	0·34
FeO	1·96	1·55
MnO	0·15	0·12
MgO	15·37	21·86
CaO	24·44	24·84
Na_2O	0·22	0·20
K_2O	0·50	0·30
Loss on ignition	1·44	
	100·49	100·00

Under II are given the molecular proportions, calculated to 100, and leaving out the loss on ignition. According to these, the proportions are as below:

$$CaO : (Mg\ Mn\ Fe)\ O = 23·53 : 24·84$$

that is, almost exactly 1 : 1. Further,

$$(Ca\ Fe\ Mg\ Mn)\ O = 48{\cdot}37$$
$$(Al\ Fe)_2\ O_3 = 2{\cdot}89$$
$$(K\ Na)_2\ O = 0{\cdot}50$$

and the molecules calculate out as follows :

1·00	(K Na)	(Fe Al)	$Si_2\ O_6$ = 3·79	per cent.
2·39	Mg	Al_2	$Si_2\ O_6$ = 9·06	"
1·55	Fe	Ca	$Si_2\ O_6$ = 5·88	"
0·12	Mn	Ca	$Si_2\ O_6$ = 0·45	"
19·47	Mg	Ca	$Si_2\ O_6$ = 73·81	"
1·85	Ca	Ca	$Si_2\ O_6$ = 7·01	"

The silica is for this composition about 2·13 molecular percent too low. This is, perhaps, caused by the fact that titanic acid is present and was weighed with the alumina. At any rate, this pyroxene is very close to diopside, the pure diopside molecule, Mg Ca $Si_2\ O_6$, requiring 55·55 SiO_2, 25·93 CaO and 18·52 MgO.

Description of phlogopite accompanying apatite.

Phlogopite is a second mineral almost invariably accompanying the apatite; many of the mines which were formerly worked for apatite being now worked for mica. The mineral is of several shades of brown, varying from light brownish-yellow, through reddish brown, to dark chestnut-brown; the most common varieties are about the colour of dark amber. Crystals are extremely common and in part of gigantic dimensions (more than 1 foot in diameter). Plates 10–15 cm. in diameter are quite common. The peripheral faces are always very rough and could not be determined with the contact gonimeter with sufficient exactness; sometimes twining forms are very common. Cleavage lamellæ exhibit no evident pleochroism and in convergent light give a dark cross which in the specimens examined from Vavasour, North Star, Cascade, Union, 'Browns', Fleury's mines and South March did not open up to hyperbolas, at least the axial angle is very small. Also the inclination of the acute bisectrix to the normal to OP is very small.

Mica examined for fluorine and lithium.

I examined a series of these micas for fluorine and lithium, as these seemed to be important in connection with the question of the origin of these vein minerals. For the recognition of lithium the micas were simply ignited in the Bunsen flame, and the red line of lithium was observed in the spectroscope in the case of the occurrences at Vavasour, Fleury, North Star and Cascade mines. A mica from the Union mine did not give the reaction. For the recognition of fluorine about 1 gram of the mica was fused with sodium-potassium carbonate, the fusion dissolved in hot water and the insoluble material

filtered off. In the filtrate the silica and alumina were precipitated with ammonium carbonate, the filtrate acidified with hydrochloric acid, the CO_2 driven off by boiling, the liquid neutralized with ammonia, and the fluorine precipitated as calcium fluoride by means of calcium chloride. From the micas from Vavasour, Union, Fleury and North Star mines a heavy flocculent precipitate was obtained which when burned with the filter and treated with concentrated sulphuric acid gave a strong etching reaction on glass. A mica from the Cascade mine gave, on the contrary, only a slight opalescence. The Cascade mine is at present an abandoned working, that was only worked for mica, while judging from the material on the dump, apatite is entirely absent.

Analysis of phlogopite from South Burgess, Ont.

No analysis of phlogopite from apatite mines north of the Ottawa river is known to me. On the other hand an analysis by Clarke and Schneider[23] is published of the phlogopite from South Burgess, Ont., so well known on account of its inclusions and its beautiful asterism. Under I its composition is given :—

	I.	II.	
SiO_2	39·66	40·24	
TiO_2	0·56	0·55	
Al_2O_3	17·00	12·96	
Fe_2O_3	0·27	7·67	
FeO	0·20	2·15	
MgO	26·49	23·29	
BaO	0·62		
CaO		0·35	
Na_2O	0·60		
K_2O	9·97		
H_2O	2·99	0·68	(Loss on ig.)
F	2·24		
P_2O_5	trace		
Total	100·60		
—O	0·94		
	99·66		

Under II is the analysis of a phlogopite from the apatite veins of Oedegarden, Southern Norway.[24] Unfortunately it is incomplete, the determination of the alkalies being wanting, but lithia and fluorine are probably absent.

Analysis I is that of a typical phlogopite, but the silica is just a little low. The small quantity of iron and the large quantities of magnesia and of fluorine are, however, characteristic. The last allies

the mica closely to the fluor micas, zinnwaldite and lepidolite. Clarke and Schneider calculate for it the formula:

$$Al(SiO_4)_3\ Mg_3K\ H_2 + Al_2(SiO_4)_3\ Mg_3K\ (MgFe)$$

combining the TiO_2 with the SiO_2, the Fe_2O_3 with the Al_2O_3, the FeO and BaO with the MgO and the Na_2O with the K_2O. The composition calculated from the formula agrees with that found upon analysis very well. A calculation of analyses I and II for purposes of comparison gave, in molecular proportions:

	I.	II.
$SiO_2 + TiO_2$	0·6610	0·6707
$Al_2O_3 + Fe_2O_3$.....	0·1684	0 1746
(FeMgBaCa) O	0·6691	0·6183

Calculated to molecular percentages the differences are, of course, smaller.

Inclusions in mica.

The much discussed inclusions which cause the beautiful asterism in the mica from South Burgess are excellently seen in the micas from North Star, Union, Fleury and Cascade mines; the mica from the North Star mine in particular contains them with relatively very large dimensions and of great beauty. These inclusions were first described and figured in detail in the mica from South Burgess by G. Rose.[25] The figures given leave no doubt that they are identical with the inclusions in the phlogopite from the North Star mine, Rose originally considered the mineral to be disthene, but subsequently concurred in the opinion of de Cloizeaux that they were a uniaxial mica. Tschermak[26] later described the inclusions and the asterism of a phlogopite from Perth. He remarks that from their refraction and form they could not be a mica, but that he was unable to determine their real nature.

In 1882 Sandberger[27] examined a phlogopite from Ontario. According to him the inclusions were contained only in the decomposed portions of the mica, which were recognized by white spots on the cleavage faces; the bright brown fresh portions of the mica on the other hand did not contain them. 'The chemical analysis showed that the almost colourless needles consisted of pure titanic acid.'

Lacroix[28] described the needle-like inclusions from a black mica from Templeton, which contained neither fluorine nor lithium. For their isolation the mica was treated in a closed glass vessel with concentrated hydrochloric acid at a temperature of 250°, and the remaining skeleton of silica which contained the needles was dissolved in a solution of caustic potash. The inclusions obtained in this way were fused with caustic potash, the mass dissolved in hydrochloric acid, and by warming

with zinc a violet colour was obtained which indicated titanium. Further the description of the rectangular and apparently hemimorphic form of certain of these inclusions agrees very well with that of the inclusions observed at the North Star mine.

Rosenbusch[29] mentions in these Canadian micas, rutile and tourmaline needles which in the same way are arranged at angles of 60° and cause asterism.

Secondary nature of inclusions in mica improbable.

It must be especially mentioned that the micas carrying inclusions which I collected, were absolutely fresh and elastic; only such are of commercial value and are mined. It seems to me therefore very improbable that the inclusions are of a secondary nature as many authors consider them to be; I consider them to be of primary formation. Their shapes are very varied. Most of them form fine needles often of astonishing length. In the mica of the North Star mine such needles were observed more than 1 cm. long, and of a thickness which under a magnifying power of 70 appeared to be equal to the cross hairs in the eye piece (eye piece 3, objective 2, Fuess). Sometimes they swell out, especially towards the ends, into a wedge shape, or they attain what Tschermak has called tobacco-pipe shape. Other forms are short and rectangular, six-sided, and then always elongated very much on one side, also eight-sided, often apparently hemimorphic, also quadratic or sharply rhomboidal. Contact twins are not uncommon, the twinning plane being one of the bounding faces, the extinction of both individuals being parallel to the division.

Varying forms of inclusions.

The accompanying sketch, Fig. 3, Plate X, gives an idea of the extraordinary and varying forms. I have measured a large number of angles with the eye piece goniometer of a large Fuess microscope. In spite of the fact of the sharp outlines reducing the errors of observation to a minimum, I hardly found two apparently similar little blades to possess the same values, so that the form gives little indication for the determination of their true character.

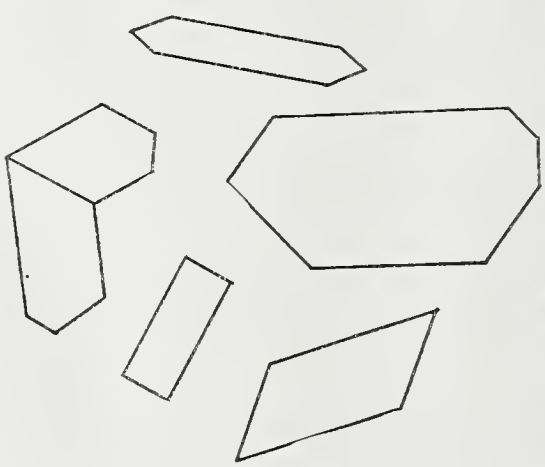


Fig. 9.

The little plates are extraordinarily thin and by

illumination with ordinary light they give pale Newtonian colours; isolated and suspended in water, the interference colours are distinctly more brilliant. Needles invariably exhibit parallel extinction, the lesser elasticity coinciding without exception with their long axis. The rectangular, six-sided, and rhomboidal forms also extinguish parallel to one of their edges, generally the longest; sometimes the greater and sometimes the lesser elasticity is in this direction. The bounding lines are extraordinarily sharp, but not very broad, so that the refractive index cannot be much greater than that of the mica. Little needles which by a magnification of 300 (eye piece 3, objective 7, Fuess) appeared hardly thicker than one of the cross hairs, were still transparent. It is therefore very unlikely that they are rutile, as is commonly supposed.

The inclusions have the usual regular arrangement, and the asterism of the mica is occasioned by them. They are absolutely unattacked by hydrofluoric acid. Thin plates of mica treated for several hours with dilute HF exhibited regular six-sided etched figures; in places where the mica has been eaten completely through, the needles remained quite unattacked. They may, therefore, be easily isolated with HF. If they are rubbed with the finger on a watch glass they scratch it distinctly. Ignited for a short time in a platinum spoon before the blast lamp they become cloudy and by reflected light dull white, and suspended in water exhibit no effect upon polarised light. Prof. Jannasch in Heidelberg had been good enough to make the following report upon an investigation which he made upon a small quantity of these inclusions isolated by me; 'There was only 0.0466 of a grain so that a quantitative analysis could not be made. Fused with B_2O_3 they gave a clear glass, in which not the smallest quantity of silica could be detected. The mineral is therefore not a silicate. The NH_3 precipitate consisted of white voluminous flocks. For separating Fe and Al the soda fusion was employed. There was no alumina but the mixture consists of a rare earth, traces of iron and some TiO_2 (yellow colouration in the acid solution with H_2O_2). The rare earth gives with soda in excess a completely insoluble white precipitate. From some preliminary reactions it exhibits the greatest resemblance to zirconia. It seems, however, to be a mixture of two rare earths. Besides the above mentioned compounds potash and soda were present in weighable quantities. On heating a sample of the mineral with concentrated H_2SO_4 on the water-bath no reaction takes place, therefore fluorine must be absent. By driving off the SO_3 decomposition takes place. A small quantity tested with $CaF_2 + K_2SO_4$ gave no B_2O_3 colouration. Probably water is also present. The quantity of

Examination of inclusions by Prof. Jannasch.

substance is much too small to characterize the bodies found. Evidently a mineral containing rare earths is present. A more exact investigation with sufficient material I consider to be very important, if you will supply me with this I shall be glad to carry out an analysis.' Upon being further asked whether the rare earth could not be TiO_2 alone, he replied that it could not, as the H_2O_2 reaction was much too weak. I am now busy isolating a larger quantity of inclusions from addititional specimens of mica kindly sent to me by Dr. Dawson.

Description of apatite crystals.

Apatite crystals are generally found in veins rich in calcite; they always exhibit a simple form $\infty P \left\{ 10\bar{1}0 \right\} P \left\{ 10\bar{1}1 \right\}$; the basal end faces I have never seen here, while they seem to be generally present in specimens from Renfrew. The edges and corners are very often rounded, which is referred by many authors to the action of some solvent. I have examined some such crystals without success for etched figures. The colour is generally green, light grass-green to dark blue-green, also brownish-green to brown. The massive portions are in part coarsely crystalline (sparry) and exhibit a fairly perfect cleavage. The crystals sometimes attain a length of several feet; from some pockets in 'pyroxenite,' masses up to 1,000 tons in weight have been found. A curious variety is the sugar-granular apatite; it consists of a fine, almost white, aggregate of apatite grains, in part so soft as to be rubbed off by the hand. Under the microscope a variety from the Little Rapids mine exhibits irregular angular or rounded forms, pretty evenly sized, and among them there is a very little pyroxene and calcite.

Analysis of Canadian apatites.

A series of analysis of Canadian apatites have been published by Hoffmann [30], Carnot [31], and Voelcker [32]:

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.
P_2O_5...	40·37	41·08	39·05	41·14	40·87	40·52	40·81	41·50	41·64
F.....	3·31	3·47	3·79	3·86	3·73	3·38	3·55	1·26	1·17
Cl.....	0·44	0·26	0·48	0·23	0·43	0·09	0·04	0·37	0·42
CO_2....	0·03	0·37	0·10	0·22	0·11	0·86	0·52	2·30	2·31
CaO....	47·83	49·16	46·33	49·34	48·48	49·04	49·10	52·90	52·90
Ca.....	3·73	3·80	4·26	4·20	4·17	3·60	3·76	—	—
MgO...	0·15	0·16	0·55	0·18	0·16	0·21	0·62	Trace	Trace
Al_2O_3..	0·61	0·71	1·19	0·57	0·84	0·27	0·57	—	—
Fe_2O_3..	0·15	0·13	1·29	0·09	0·91	0·08	0·13	0·22*	0·30†
Insol...	3·89	0·37	3·49	0·06	1·15	1·63	0·63	0·30	0·37
								$=SiO_2$	$=SiO_2$
Total...	100·51	99·51	100·53	99·89	100·85	99·68	99·93		

* with 1·30 FeO † with 1·20 FeO.

I. Apatite from lot 14, range 6, township of Storrington—Hoffmann.
II. " Grant mine, township of Buckingham "
III. " lot 16, range 3, township of North Burgess "
IV. " Ritchie mine, township of Portland "
V. " lot 10, range 10, township of Loughborough "
VI. " Watt's mine, township of Portland "
VII. " 'Doctor' Pit, township of Templeton "
VIII. Inner part of a dark-green crystal from Templeton—Carnot.
IX. Outer part of the same crystal.—Carnot.

Two analyses of Canadian apatite by Voelcker gave :

	X.	XI.
Moisture	0·04	—
Loss on ignition	0·25	—
$Ca_3P_2O_8$	89·36	90·31
$CaCo_3$	1·95	—
$CaSO_4$	0·54	—
$CaCl_2$	0·14	0·75
CaF_2	4·54	5·03
MgO	0·19	
F_2O_3	0·41	0·24
Al_2O_3	0·86	0·99
Insol. res	0·15	0·99
CaO	1·72	2·27
	100·15	100·58

Material used in analyses not free from inclusions.

Evidently all the analyses have not been made upon material free from inclusions. The difference in the amount of fluorine in the first seven analyses to that shown in those following is remarkable. Certainly in these first ones the determinations are too high. Since pure fluorapatite contains only 3·77% F, it is impossible that 3·79% F in analysis III with an insoluble residue of 3·49% can be correct. From the quantities of F and Cl present may be calculated :

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.
CaF_2	6·80	7·13	7·78	7·93	7·66	6·93	7·30	2·58	2·40	4·54	5·03
$CaCl_2$	0·69	0·41	0·74	0·36	0·67	0·13	0·06	0·58	0·66	0·14	0·75
CaF_2 in %	91	95	91	96	92	98	99	82	80	97	87

The Canadian apatites are therefore distinguished by a very high proportion of fluorine ; in part they are almost pure fluorapatite ; the proportion of fluorine molecule to chlorine molecule is always greater than 4:1. The same is true of the apatite in tin ore veins and of the apatite and phosphorite which are also vein formations, partly in granite, in the province of Estremadura, in Spain. In contrast with this are the vein apatites of southern Norway, almost free from fluorine. In twenty crystals from Krageroe, Voelcker could not recognise fluorine.

Calcite is,as has already been stated, always the latest formed mineral in the veins; I have never seen crystals, the mineral forming a coarse-grained mostly reddish-coloured aggregate in the central part of the veins in which the finest apatite crystals occur. It is peculiar that many apatite crystals possess a nucleus of calcite. This may be explained by the former mineral having a sort of skeleton growth and the resulting cavities having been filled up later with calcite.

Feldspars of common occurrence with apatite.

Feldspars are extremely common in many occurrences of apatite. It is especially a grey-coloured microcline, forming coarsely crystalline aggregates which in many places cover large surfaces of the walls of mines. At the Cascade mine I found crystals of a plagioclase exhibiting the faces 0P $\left\{ 001 \right\}$ $\infty'P\breve{\infty}$ $\left\{ 010 \right\}$ ∞P^1 $\left\{ 110 \right\}$ $\infty^1 P$ $\left\{ 1\bar{1}0 \right\}$ $\infty P\breve{3}$ $\left\{ 130 \right\}$ $\infty^1 P\breve{3}$ $\left\{ I\bar{3}0 \right\}$ $^1P^1$ $\bar{\infty}$ $\left\{ I01 \right\}$ P_1 $\left\{ \bar{1}\bar{1}1 \right\}$ P^1 $\left\{ I11 \right\}$ Cleavage plates parallel to OP and $\infty P\breve{\infty}$ give extinction angles of 3° and 11-12° respectively; it is therefore an andesine of the composition Ab_4 An_3. The crystals are elongated in the direction of the a axis. They are about 5 cm long with very rough surfaces, Fig. 10. They are supported partly upon compact pyroxenite, partly upon a network of small pyroxene crystals. At the Vavasour mine I collected masses which consisted of a coarsely crystalline microcline, a light-green plagioclase, and green pyroxene. The single individuals are sometimes over 8 cm in diameter. The plagioclase has on 0P an extinction angle of almost 0°, and

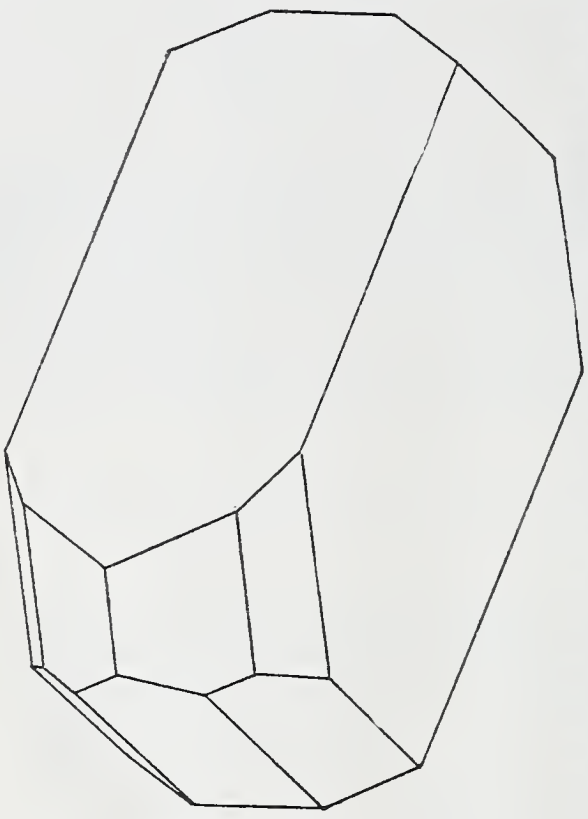


Fig. 10.—Feldspar from the Cascade Mine.

s therefore andesine. Harrington[9] mentions also orthoclase and albite from the apatite veins.

Amphibole was seen principally at the Little Rapids mine in masses composed of little rods and parallel fibres. It is a light-green actinolite. Harrington also describes the change of pyroxene crystals into uralite.

Tourmaline is in certain places very plentiful. In one of the pits of the Crown Hill mine a whole wall is covered with black tourmaline. At the Little Rapids mine I found black tourmalines, brown by transmitted light, 0·5 cm long, in calcite, and also on quartz, with the termination $+ R \{10\bar{1}1\} - \frac{1}{2} R \{01\bar{1}2\}$. Tourmaline abundant.

Scapolite crystals are mentioned by Harrington from various apatite veins; they attain more than a foot in length and in many cases are very rich in faces. I found only parallel-fibrous masses, which, however, were extraordinarily widely distributed in the Crown Hill, Union and High Rock mines where they cover whole walls. Adams has analysed a scapolite from lot 13, range 8, township of Ripon and obtained the following composition: Scapolite crystals.

SiO_2	54·86
Al_2O_3	22·45
Fe_2O_3	0·49
MgO	trace.
CaO	9·09
Na_2O	8·37
K_2O	1·13
Cl	2·41
SO_3	0·80
H_2O (combined)	0·72
H_2O (hygroscopic)	0·14
	100·46
—O	0·59
	99·87

This scapolite corresponds pretty closely to the composition Me_1Ma_2, to Me_2Ma_3. Microscopically the mineral is found to be extraordinarily widely distributed in the 'pyroxenite.'

Metallic minerals are represented by pyrite, chalcopyrite and pyrrhotite. In many pits of the Emerald mine the pyroxenite is penetrated through and through with pyrrhotite and pyrite, and the material on the dump is coloured brown by iron. Metallic minerals.

Titanite in the usual form $\frac{2}{3}$ P 2 $\{123\}$ OP $\{001\}$ $\frac{1}{2}$ P $\dot{\infty}$ $\{102\}$ is found in all the veins. A portion of the vein from the Little Rapids mine consists essentially of grey microcline in which there are green pyroxene crystals and titanite crystals over a centimeter across.

Fluorite seems to occur rarely. Harrington mentions it from several localities, but says also that even in these localities it occurs in small amount. Only at the North Star mine did I see any violet fluorite. The mineral may of course occur also of a green colour and then upon a superficial examination of the dumps be mistaken for apatite.

Quartz not common.

Quartz also is not common. Massive pieces associated with tourmaline and actinolite, I saw at the Little Rapids mine. At the Vavasour mine the workmen showed me a small drusy cavity which was completely lined with quartz crystals and a white lithomarge-like mass; the calcite was at this place unusually coarsely crystalline and contained some chalcopyrite. The quartz crystals, as clear as water, and about 0·5 cm. long, exhibit the simple combination— ∞ R. $\{10\bar{1}0\}$ + R. $\{10\bar{1}1\}$ − R $\{01\bar{1}1\}$; Harrington mentions also smoky quartz and amethyst. Crystals appear to be found only upon the walls of cavities, which would justify the conclusion of a relatively younger age.

Other minerals.

The other minerals mentioned by Harrington, of which particularly zircon and garnet appear to be widely distributed, I did not find during my short stay. In Templeton township, zircon crystals are said to occur more than a foot long. The occurrence of molybdenite (lot 12, range 12. township of Templeton) and graphite is interesting, the former because it is the most usual associate of cassiterite in the tin veins, the latter because in the graphite veins north of Ottawa, *e.g.* in Walker's mine, green apatite occurs in large massive pieces. A close relationship of the two kinds of veins is therefore indicated. According to Vogt[33], the apatite of Odegaarden in Bamle is in places rendered impure by a carbonaceous substance.

Eruptive rocks which accompany the apatite veins (pyroxenite in part). It is characteristic of all the rocks here referred to that they possess the eugranitic granular structure of typical plutonic rocks. As to their mineral composition, most of them consist essentially of a lime-soda feldspar which is either labradorite or a variety closely allied to it,

and of members of the pyroxene family (augite, diallage, and a rhombic pyroxene poor in iron), with which some mica and a primary green hornblende are associated. Olivine was never observed, but quartz is present in subordinate quantities. They are therefore in general rocks of the gabbro family, with transitions to norites, diorites, shonkinites, and pyroxenites. What name is to be given to each individual rock cannot be definitely stated on account of the rapid development in petrographic nomenclature and the varying definitions given to such terms as augite-diorite, hornblende-gabbro, mica-gabbro, &c. A real definition of these terms will be possible only when, along with the qualitative mineralogical composition, the quantitative is also taken into consideration, especially the relation of the dark components to the feldspars, the alkali feldspars to the lime feldspars, and the general basicity. These are the factors which in the formulæ of rocks are expressed by the numbers *s a c f*. For such a classification analyses are certainly necessary, but without these a solution of the confusion here existing is impossible. I will therefore here conform to the tables IV. and V, given on page 467 and 468 of my work, and call those rocks which accord with table IV. diorites, mica-diorites, augite-diorites, enstatite-diorites, norite-diorites, and those corresponding to table V. mica-gabbros, hornblende-gabbros, enstatite-gabbros, norite-gabbros. To be sure the lower part of table IV. and the upper part of table V. form transition members which may with equal right be called by either name.

Petrographic nomenclature.

Unaltered Rocks, in part not Scapolitised.

Enstatite-gabbro from the Emerald mine.—At Murray's pit, near the top of the hill, along the sides of which the various pits of this mine are located, there are found large blocks of a very fresh plutonic rock which evidently come from the quarry which can no longer be entered. It is a rather coarse, dark-gray, very tough rock, that is seen under the magnifying glass to consist essentially of triclinic feldspar and pyroxene. There is also present a reddish-brown mica, which is, however, not uniformly distributed, but as is well seen in the blocks, is collected into lines which form a network with one another. They are evidently joint planes (Absonderungsklüfte) in which the mica has been formed. Running off from these cracks, parallel to which the rock breaks most easily under the hammer, some isolated plates of mica have penetrated the normal rock ; large parts of the latter are quite free from mica. Undoubtedly we have here to deal with a later formation ("Neubildung") which is connected in origin

Enstatite-gabbro.

with the apatite and mica in the neighbouring veins. These planes of jointing were the places where the penetration of vapours and solutions would meet with the least resistance, and therefore where secondary minerals would be first expected.

Microscopic description of enstatite-gabbro.

Under the microscope one sees that plagioclase and pyroxene are present in almost equal quantities, the latter, perhaps, predominating to a slight extent. Both generally form irregularly bounded grains.

The plagioclase is very fresh and exhibits the usual twinning striæ, according to the albite law and in part the pericline law. Cleavage plates parallel to oP gave an extinction angle of about 10°, the specific gravity determined by pycnometer was 2·694, and the mineral, therefore a typical labradorite.

Two pyroxenes are present, a monoclinic and a rhombic one. The monoclinic is transparent and of a very light green-gray colour. Pleochroism is hardly perceptible. Besides the cleavage parallel to ∞P, there is a less perfect one parallel to $\infty P\breve{\infty}$; the lamellar structure of diallage, however, is absent. Small leaves of mica have formed in the cleavage cracks of the second order above mentioned. A slight alteration into uralite, beginning at the edges, has taken place.

The rhombic pyroxene is less abundant than the monoclinic. Its sections often have a rude prismatic development. It is colourless and transparent, but in thicker sections exhibits a slight pleochroism between reddish and greenish tones. A high relief, due, perhaps, to its fibrous nature, its very low interference colours, and parallel extinction in sections from the prism zone, enable it to be easily distinguished from the monoclinic augite. An alteration into a green serpentine-like mineral, perhaps bastite, has taken place along rough irregular cross-cracks. Inclusions of little opaque rods are very common, and are arranged in rows parallel to the c. axis of the host.

The mica is transparent with a reddish-brown colour, and in convergent light appears to be uniaxial; the pleochroism is between straw-yellow and red-brown. The detection of fluorine in this mica was of special interest; if its formation is secondary and connected with that of the apatite and phlogopite of the veins, it was to be expected that it also should contain fluorine. In fact, the carefully purified mineral gave a strong fluorine reaction. Apatite in rounded grains is fairly abundantly present in the rock.

Analysis by Dr. Dittrich.

Dr. Dittrich made an analysis of this enstatite-gabbro. Material was chosen for this purpose which was free from the above-mentioned

mica veins, and which, therefore, contained mica only in very small quantities :

	I.	II.	Ia.
SiO_2	49·32	53·76	50·87
TiO_2	0·42	3·70 (impure)	0·32
Al_2O_3	13·33	13·35	8·09
Fe_2O_3	1·28	11·59	
FeO	7·76		7·65
MgO	11·13	7·22	17·22
CaO	11·73	6·92	12·97
Na_2O	2·12	1·70	2·12
K_2O	1·12	0·30	0·74
P_2O_5	0·06	....	0·02
H_2O	0·64	0·71 (loss on ig.)	
CO_2	0·89	....	
	99·82	99·25	

Analysis for comparison.

For comparison the analysis of an olivine hyperite from Lofthus in Snarum has been given under II., as a type of the gabbro accompanying the apatite veins in southern Norway. Ia. gives analysis I. in molecular proportions, calculated to 100. From it may be calculated

s	A	C	F	a	c	f	n
51·19	2·86	5·23	32·61	1·5	2·5	16	7·4

and the formula $s_{51}\ a_{1\cdot5}\ c_{2\cdot5}\ f_{16}\ n_{7\cdot4}$. The rock therefore belongs between the types Molkenhaus Subitelma and Keewenaw, with which the silica agrees in a satisfactory manner. It is on the boundary of the α and β series. As average plagioclase we obtain $Ab_{5\cdot72}\ An_{5\cdot23}$ or almost $Ab_1\ An_1$, which agrees very well with the specific gravity 2·694.

Gabbro from Smithy at Emerald mine

Another very fresh gabbro was obtained from the smithy, of the Emerald mine, lot 18, range XII. This uniform rather coarse rock also consists of almost equal quantities of very fresh plagioclase and pyroxene, but mica and rhombic pyroxene are entirely wanting. The feldspar commonly exhibits undulose extinction, with bent and cracked twinning lamellæ, probably pressure phenomena. The augite is completely dusted through with tiny inclusions, which by employing an immersion objective are seen to be liquid inclusions with movable bubbles. The formation of uralite has gone somewhat farther than in the gabbro from Murray's pit. Sulphides and apatite are scarce.

A gabbro from the dump of the Squaw Hill mine contains large quantities of red-brown mica ; these works are on the same hill as the Emerald mine. It is distributed very evenly through this somewhat

fine-grained rock, so that its primary or secondary nature is difficult to determine. The rock is free from rhombic pyroxene, but relatively rich in apatite.

Apatite rare in Cascade mica mine.

The veins of the Cascade mine on the Gatineau river, are distinguished by their poverty in or absolute want of apatite. They are worked only for mica, and apatite is exceedingly rare on the dumps. The principal rock of the hill is also a basic plutonic rock. The typical variety from the railway cutting directly on the river is a uniform medium-grained gabbro of irregular structure, in which may be seen with the unaided eye, fresh feldspar with twinning striæ, some brown mica and a good deal of augite. Plagioclase and augite are present in about equal quantities. The hand specimens which were collected from the mine on the contact against the later-formed 'pyroxenite' and other vein fillings exhibit a somewhat gneiss-like appearance. Augite and plagioclase are arranged in lenticular masses, so that the surface on the main fracture has a light and dark spotted appearance, the cross fracture being somewhat streaky owing to the alternation of the lenticles; the grain is also somewhat finer. At the contact with the pyroxenite the rock is completely penetrated by honey-brown titanite crystals and grains and is very rich in pyrite.

The rock from the railway line shows under the microscope an absolutely irregular structure, neither plagioclase nor pyroxene show crystalline boundaries. Cleavage lamellae of the former give an extinction which on P varies from 3—13° and on M from 7—25°; it therefore belongs to the andesine-labradorite series. Even with the magnifying glass it is seen that many of the cleavage faces are bent. Under the microscope, undulose extinction, bent and broken twinning lamellæ are very common. The rock has certainly suffered great pressure. The pyroxene is transparent, of a light green-gray colour; pleochroism is hardly perceptible. Sections normal to c exhibit, besides the cleavage parallel to the prism, well developed cracks parallel to $\infty P\bar{\infty}$ and very numerous fine cracks, parallel to $\infty P\breve{\infty}$, running only short distances, so that a fibrous appearance is developed. One optic axis is almost perpendicular to this section. Polysynthetic twinning according to oP is very common. The formation of uralite has gone quite far, proceeding from the cracks parallel to $\infty P\bar{\infty}$ and those connected with the formation of the above mentioned twins. Lamellæ converted into uralite often alternate with others of the unaltered mineral. The uralite is green and shows relatively weak differences of absorption, the pleochroism varies from light greenish-yellow to light grass-green. In a section almost parallel to $\infty P\bar{\infty}$ the augite shows an extinction angle of 39—

40°, the uralite 15° and in both c differs from c in the same sense. In the cleavage cracks and the separation cracks parallel to oP the same rod and plate-like inclusions are found as is the case of the hypersthene of St. Pauls island, only here they are scarcer and not so regularly distributed.

Microscopic description of contact rock from Cascade mine.

The mica forms little plates which collect into small knobs or are arranged radially about a large sulphide or pyroxene grain. The mica is undoubtedly younger than the pyroxene. A part of it appears also to have been derived from the uralite. Small plates of mica are grouped as a fringe around the hornblende rods or the hornblende is completely penetrated by them peripherally.

The rock from the contact with the pyroxenite in the Cascade mine is seen under the microscope to be distinctly finer-grained, and the contours of the grains are more rounded. The polysynthetic twinning striæ of the feldspars are replaced more or less by a fibrous appearance which passes over into microperthitic intergrowths. A very common appearance is that the centre of the feldspar grains consists of a cloudy partially decomposed core, which is surrounded by a narrow unaltered edge as clear as water, the optical orientation of the two parts is generally somewhat different. Doubtless a development of secondary feldspar has here taken place. The pyroxene is somewhat darker in colour and more strongly pleochroic than in the rock from the railway cutting. It contains the same opaque or red-brown transparent inclusions. Besides an alteration to hornblende, epidote is also widely distributed. As has already been mentioned in the macroscopic description, titanite occurs very abundantly, the pyroxene slightly predominating over it. It is strongly pleochroic in almost colourless and reddish-yellow tints and frequently shows polysynthetic twinning. The very common pyrite has also been mentioned above. Evidently pyrite and titanite, and perhaps also part of the feldspar, are here alteration products, whose origin is connected with the formation of the 'pyroxenite.'

Gabbro from South March.

Gabbro from South March, about twenty miles west of Ottawa. This rock, which is cut through by a series of apatite mica veins which have here and there been opened up, is also a typical plagioclase augite rock. The absolutely unaltered plagioclase here also shows distinct signs of pressure. Large individuals are frequently broken up; in such places microperthitic intergrowths occur and also some quartz. The plagioclase is extraordinarily rich in hair-like microlites, which are so common in quartz. They are sometimes straight, sometimes bent like trichites, and are arranged absolutely irregularly with respect to

one another. Their thickness is so small that they are usually transparent. In isolated thick ones high double refraction and parallel extinction are evident, and it is not improbable that they are rutile. The pyroxene, transparent with very light green-gray colour, is to a large extent converted into uralite ; the uralite has, in places, been converted into mica. Opaque metallic grains are surrounded by leucoxene edges and are probably titanic iron ore.

Shonkinite from Crown Hill mine.

Shonkinite from the Crown Hill mine.—This rock which differs chemically considerably from the plutonic rocks already described, is found in a small prospect hole on the river side of the slope on the line of the wire rope tramway, built to transport apatite from the Union mine to the Lièvre river. The uniform, medium to coarse-grained, unaltered rock is very rich in dark-coloured constituents, in which dark-gray pyroxene and to a less extent brown mica can be recognized macroscopically. Feldspar is present in very much smaller quantity. The structure is that of a typical plutonic rock ; all parallel structure is completely absent. One would conclude from the macroscopic appearance that it was a micaceous gabbro or basic monzonite.

Microscopic description.

Under the microscope none of the principal constituents exhibit idiomorphic outlines. The feldspar is almost absolutely free from twinning lamellæ and is a typical microperthite ; extinction was determined on some cleavage lamellæ, on OP parallel, on ∞ P $\breve{\infty}$ as 7°. The little plates between crossed nicols get uniformly dark, probably on account of the extraordinary fineness of the intergrown lamellæ. The optical behaviour, and the strong predominance of potash over soda in the general analysis make it certain that the principal part of the feldspar is orthoclase. On cleavage faces parallel to ∞ P $\breve{\infty}$ the inclination of the very regularly penetrating threads to the cleavage cracks parallel to OP was 74-75° ; on oP they lie normal to the cleavage parallel to ∞ P ∞. The plane of interposition is therefore an orthodome, which, as in murchisonite, corresponds approximately to 7 P $\breve{\infty}$. Many feldspar grains upon strong magnification exhibit in their peripheral portions an extremely fine twinning striation ; perhaps this is an anorthoclase.

A lime-soda feldspar is present only in very small quantities. It is, unlike the unaltered microperthite, always filled with alteration products in the form of strongly double-refracting threads and plates.

The augite, transparent with a very light-green colour, does not exhibit anything remarkable ; it is in the first stage of uralitisation. Part

of the green weakly pleochroitic hornblende is certainly primary. The mica is frequently intergrown regularly with the hornblende and then no doubt partially derived from it. If a large hornblende section is rotated till it is dark, a number of fine lamellæ, strongly doubly refracting are seen parallel to the cleavage cracks, which may, upon high magnification, be recognized as mica. The mica also surrounds the hornblende and extends into the cleavage cracks and fractures. On the other hand, larger mica plates are certainly primary. As accessory constituents titanite and metallic minerals may be mentioned, the latter on account of their behaviour in reflected light seem to consist essentially of pyrite.

Analysis of shonkinite by Dr. Dittrich.

An analysis of the rock was made by Dr. Dittrich. In spite of the fact that almost all the determinations were made in duplicate with nearly identical results, the total came to 98·66% only. At my request examinations were made for fluorine and chlorine; fluorine was absent, and chlorine present only in traces (not more than 0·1%). Where the loss is cannot be guessed.

	I.	II.	III.	IV.
SiO^2	48·60	47·85	46·53	48·98
TiO^2	0·79	.....	2·99	1·44
Al^2O^3	13·60	13·24	14·31	12·29
Fe_2O_3	2·30	2·74	3·61	2·88
FeO	4·97	2·65	8·15	5·77
MgO	8·79	5·68	6·56	9·19
CaO	10·00	14·36	12·13	9·65
Na_2O	1·42	3·72	4·95	2·22
K_2O	5·62	5·25	1·58	4·96
P_2O_5	0·19	2·42	.....	0·98
H_2O	0·61	2·74	0·20	0·56
CO_2	1·23	.....	MnO 0·22	MnO 0·08
SO_3	0·54	.....	.....	BaO 0·43
				SrO 0·08
				F 0·22
	98·66	100·65	101·23	99·73

Analysis for comparison.

No. II, an analysis of nepheline-pyroxene-malignite from Poobah lake, Rainy River district; No. III, theralite from Kunjokthal, Umptek Kola; and No. IV, shonkinite, from Yogo Peak, Little Belt Mountains, Montana, have been introduced for comparison. No. IV agrees best with No. I both in alkalies and the proportion of CaO to MgO and FeO. No. II is poorer in FeO and MgO, but richer in CaO. In III the proportions of alkalies are reversed. Undoubtedly the rock from Crown Hill mine belongs to this family. A reduction to molecular percentages (all iron calculated as FeO) gives:

SiO_2	52·83
TiO_2	0·65
Al_2O_3	8·69
FeO	6·38
MgO	14·33
CaO	11·65
Na_2O	1·49
K_2O	3·90
P_2O_5	0·08
	100·00

Consequently

A = 5·39 ; C = 3·30 ; F = 29·06 ; a = 3 ; c = 1·5 ; f = 15·5 ; n = 2·4 giving the formula

$$S_{53\cdot5}\ A_3\ C_{1\cdot5}\ F_{15\cdot5}\ N_{2\cdot4}.$$

The rock is very similar to the theralite type Kunjokthal, the silica agreeing very well also. The proportion of alkalies places it in the E series. While the rocks described contain much feldspar, veins occur in the gneiss near the London mine which are very poor in feldspar, and which, I believe, in part at least belong to the same category of plutonic rocks. They consist essentially of augite and enstatite and form therefore a transition to *pyroxenites* in the sense of the petrographic nomenclature (*websterite*). The colourless and sometimes also weakly pleochroic enstatite forms roughly outlined prismatic crystals and is always older than the monoclinic augite. It exhibits the usual fibrous texture, parallel to the c axis, across which run irregular wide cracks in which the alteration into a green alteration product begins. The augite does not show any peculiarities worth mentioning. The sparse plagioclase fills up the vacancies between the pyroxenes. The red-brown mica is, judging from the whole manner of its occurrence, a new formation. It develops most readily along the cleavage lines and cracks of the pyroxenes, or in little angular wedges between the other constituents.

Secondary pyroxenites.

Minerals of secondary formation.

The minerals, which in the form of more or less well developed crystals or coarsely crystalline and fibrous masses, occur in the apatite veins, especially those developed in the calcite of the central portions, have been already spoken of. Here we are concerned with mineral aggregates which form preferably upon the edges of the veins and on account of their somewhat uniform grain remind one in their habitus of plutonic rocks. In all these masses pyroxene is the predominating

constituent, phlogopite, apatite, scapolite, and metallic minerals also occurring widely distributed. In part they are very difficult to distinguish from altered plutonic rocks; here only typical secondary formations will be described. According to their mineral constitution they may be classed as:

1. Pure pyroxene aggregates.
2. Pyroxene-phlogopite aggregates.
3. Pyroxene-apatite aggregates.
4. Pyroxene-scapolite aggregates.

Between these groups there exist, of course, all possible transitions. Here, therefore, only certain types can be dealt with. Pure pyroxene aggregates.

Almost *pure pyroxene aggregates* have been obtained from the Brown, Vavasour, Little Rapids and Squaw Hill mines. They are rather coarse, quite irregularly arranged masses of light-green, gray, or reddish-gray colour, which in part (Brown mine) are very richly impregnated with pyrite. Microscopically, they consist of an aggregate of irregularly outlined almost colourless augite grains with which are associated, generally in the form of little patches, calcite, scapolite, and phlogopite in small quantities. The pyroxene has often an exceptionally cracked appearance, or is perforated like a sieve and filled with particles of the above mentioned accessory minerals. Apparently these are not original inclusions but corrosion phenomena. The pyroxene originally formed, was corroded by solutions or vapours and the hollows thus formed were filled with later formed minerals.

I collected a very peculiar "pyroxenite" from the dumps of the Little Rapids mine. It consists entirely of a very loose aggregate of light-gray, highly lustrous rounded pyroxene grains and may be crumbled between the fingers. The grains are about 1 mm. in diameter, and the rock at the first glance does not look unlike a perlite. Massive green apatite is attached directly to the piece.

Pyroxene-phlogopite aggregates have already been described from the Vavasour mine and are found very typically and widely distributed also at the Cascade mine; they contain almost equal quantities of mica and pyroxene. In the specimens from the Vavasour mine, the latter is grass-green, about the colour of chrome diopside, and forms a loose granular mass, partly crumbling between the fingers. In this occur yellow-brown phlogopite plates, mostly arranged in a parallel manner. Contact specimens show that the cleavage planes are normal to the border of the vein. From the gneiss in which Pyroxene phlogopite aggregates.

the vein occurs, this mass is separated by an aggregate of pure pyroxene about 1 cm. thick, which in part exhibits a fibrous structure; the fibres are placed perpendicularly to the wall of the vein. Upon the first glance one sees that such a banded structure has nothing to do with the parallel structure of the gneiss; further, the contact with the gneiss is absolutely sharp. The size of the grains of this pyroxene phlogopite mixture is very uniform, about 0·5 cm. diameter.

Augite phlogopites.

The augite in the specimen from the Cascade mine is somewhat darker, but in sections is almost colourless and transparent. Every where it is seen, from the way the phlogopite plates are wedged in between the pyroxene, that they are younger than the latter.

Other augite phlogophite aggregates from the Vavasour mine exhibit a very peculiar structure. The light grey-green pyroxene forms large, rounded elliptical masses (augen) several centimeters long and generally much elongated in one direction; they possess continuous cleavage, and consist of one individual; between them there is a considerable aggregate of phlogopite, and some fine-grained augite. Plate IV. shows such a vein mass. The lenticular 'augen' are all arranged with their longer axes parallel, so that upon first glance there seems to be a similarity to the structure of a foliated augen-gneiss. The phlogopite plates of the interposed material, however, are arranged almost without exception with their planes normal to the surface of the contiguous pyroxene lenses. The lower part of the figure exhibits a 2-3 cm. thick zone of actinolite; upon it lies, with fairly well defined boundary, the central portion of the vein material rich in calcite.

Another peculiar structure is exhibited by pyroxenites from the Fleury mine. In the main mass consisting of pyroxene, are embedded at distances of 2-3 cm., roundish lumps rich in phlogopite and also containing some calcite.

A transition to the next group is represented by the widely distributed *pyroxene-phlogopite-apatite* aggregates of the Vavasour mine.

Pyroxenite from Union mine.

A type of a 'pyroxenite' consisting of *augite* and *apatite* I obtained from the Union mine. Plate III shows that the pyroxene is without sharp crystallographic outlines, and forms rough prisms arranged parallel, about 0·5 cm. long, among which is a granular aggregate of green apatite; the whole arrangement reminds one of flow structure. In sections, the apatite grains are seen to be penetrated by dark stripes which upon higher magnification are seen to be closely aggregated tube-like fluid inclusions. In what relation the position of the pyroxene stood to the walls of the vein could not be determined, as the piece was taken from the dump.

Pyroxene-scapolite aggregates.—This group leads over into the altered gabbros. A sharp division between the two is, as has already been pointed out, impossible, as a large portion of the material had to be collected from the dumps. Criteria for such a division might be sought in the method of occurrence and in the microscopical structure of the pyroxene, (if one might postulate that by the scapolitising of the gabbro this mineral had not been essentially changed), and also in the structure of the whole mass. Both considerations, however, lead to no definite results. In most cases augite and scapolite form an irregular granular aggregate, as was the case with the augite and plagioclase in the above mentioned plutonic rocks. Occasionally when scapolite is richly represented there is developed a honeycomb-like structure which is so beautifully observed in the 'spotted gabbro' from Oedegaarden. The transition from plagioclase to scapolite is seen in only very few sections, as the material adhering to the walls of the mines and that thrown out upon the dumps is generally completely altered. Pyroxene-scapolite aggregates.

Only the two occurrences at the Emerald mine spoken of on p. 21 can be described as certainly secondary formations of this kind. Both form selvages about 5–8 cm. thick to veins whose inner portions consist of pure apatite. In both cases these apatite veins cut pegmatite which in its turn occurs as veins in gabbro and gneiss. The contact of the outer zones against the pegmatite is absolutely sharp.

Both aggregates possess a light reddish-gray colour and exhibit macroscopically, besides the augite, only some green apatite grains and some pyrite. The scapolite is first seen under the microscope. Here the distribution of the two principal constituents is seen to be very irregular. Some portions of the section consist almost entirely of the colourless transparent augite with little scapolite, in others the latter distinctly predominates. Frequently it forms large rod-like individuals in which augite grains are poikilitically developed. Other portions of the sections exhibit both minerals in almost equal quantities in the form of equally large grains bounded by straight lines, so that a honeycomb pavement-like structure is produced. The scapolite has the opaque rod-like enclosures which are highly characteristic of this mineral and which are arranged parallel to the c axis. In the occurrence at the smithy it is to a great extent altered into an aggregate of colourless strongly doubly refracting little plates which are probably muscovite. The cleavage of the scapolite is always well developed, so that in longitudinal sections it reminds one strongly of muscovite on account of its feeble refraction and high double refraction. Cross Description of pyroxene-scapolite aggregates.

sections and the optical orientation of the longitudinal sections enable one to distinguish it easily from this mineral, however. Phlogopite is also found in varying quantities in this augite scapolite mixture.

Altered plutonic rocks and 'pyroxenites,' in part, consisting essentially of augite and scapolite.

Altered plutonic rocks.

To the above described mixtures which on account of their geological occurrence are certainly to be characterized as vein formations, must be added a large number of hand specimens collected at almost all the mines visited. They are dark-gray medium to coarse-grained mixtures of augite and scapolite of completely massive appearance which macroscopically exhibit the greatest similarity to gabbros. Under the magnifying glass one sees that the colourless constituent does not possess the good cleavage and the twinning striæ of plagioclase. The fracture is irregular, often fibrous, the lustre more greasy, so that this is probably the reason why many authors mention the frequent occurrence of quartz in the pyroxenite. Generally, as has already been pointed out, the microscopic examination reveals no traces whatever of the genesis of these masses. As everywhere the same relations are repeated, only certain occurrences, which I hold to be undoubtedly altered plutonic rocks, need be here described.

Scapolite gabbro from Vavasour mine.

Scapolite gabbro from the Vavasour mine.—This is a somewhat coarse-grained rock. Among the darker constituents hornblende may be recognized by its good cleavage. The colourless mineral may without difficulty be distinguished from plagioclase under the magnifying glass. Its poor cleavage, and a somewhat greasy lustre remind one of nepheline; it is frequently fibrous in structure. Pyrite is widely scattered through the rock; brown mica is found only here and there, but in plates nearly a centimetre across. Some epidote can also be seen macroscopically.

Under the microscope the light green-grey transparent pyroxene is seen to form irregular or roughly prismatically outlined grains which, as in gabbro, are often collected together into little lumps. Externally and along the cracks, the augite has become altered into uralite and here and there into epidote. It is also very noticeable here how it is eaten out like a sieve, and everywhere scapolite and phlogopite have been formed in the holes. The latter is seen by fairly high magnification to be wedged in between the augite in the cleavage cracks in long thin plates. Fig. I., Plate X.

The quantity of the scapolite seems much greater under the microscope, because alteration having begun and the mineral having thereby become opaque and dirty-looking it is difficult to distinguish it macroscopically from the augite. Cleavage and optical behaviour in parallel and convergent light, easily prevent its being mistaken for other minerals. In places which are rich in scapolite the above mentioned pavement-like structure is very distinct; see Fig. I., Plate VIII. Cross sections as well as longitudinal ones often exhibit very regular hexagonal contours. The specific gravity of the unaltered scapolite was determined as 2·64 by means of the pyknometer; according to Tschermak's data this corresponds to a mixture of about 36–40% Me to 60–64% Ma. Primary hornblende is entirely wanting.

Similar relations are found in the other hand-specimens examined. The pyroxene is generally very fresh. The scapolite usually exhibits the little rod-like or six-sided opaque inclusions (Fig. 4, Plate X.) which are probably titanic iron. It is much more subject to decomposition than the pyroxene, and thereby becomes fibrous and dark-coloured by a substance, not determinable, being scattered through it like dust. Then it passes over into the laminated aggregate so often referred to. The proportions of pyroxene and scapolite vary very much; usually the former predominates. The pyroxene sometimes shows rough crystallographic outlines, the scapolite never. Phlogopite occurs in many of the rocks, but always exhibits relations which point to its secondary origin, which is certainly connected with the formation of the apatite. The content of metallic minerals is very variable; in most cases it is very small, in others pyrite, pyrrhotite and also some chalcopyrite may be distinguished macroscopically; these are unmistakably impregnations. Apatite is also found abundantly, many sections are completely covered by a network of little veins of it; its formation here is also secondary.

Transition of pyroxenite visible.

A scapolitized gabbro from Poupore post office is very rich in tremolite and epidote. An old apatite opening there is altered into a light-green coloured 'pyroxenite,' which, macroscopically, is seen to contain abundant colourless hornblende. Green actinolite, in company with calcite, forms the filling of veins which traverse the rock in all directions. At one place in the cut, the transition of the 'pyroxenite' into a dark blue-gray, medium to fine-grained rock, is visible, which, with a completely massive habitus, has the appearance of a diorite or gabbro poor in feldspar. It is richly powdered all through with particles of secondary pyrite. Under the microscope, the constituents are seen to

be quartz, triclinic feldspar, very abundant green hornblende, epidote and scapolite. The quantities of quartz and feldspar are very different in different specimens; in many they are almost entirely wanting, while in others they constitute almost a quarter of the whole rock. Amphibole and scapolite are poorly outlined crystallographically; they form irregular grains, the former also often rod-like forms. The amphibole is very light-green or quite colourless and transparent, in the former case with weak pleochroism; and, is probably a form intermediate between tremolite and actinolite. Scapolite, with the usual properties, is much altered. The epidote must be a secondary product, and forms crystals elongated parallel to the b axis, and usually well and sharply outlined. Sections perpendicular to b are six-sided bounded by ∞ P $\breve{\infty}$ $\{100\}$ 0 P $\{001\}$ and + P $\breve{\infty}$ $\{\bar{1}01\}$. Cleavage cracks parallel to OP and ∞ P $\breve{\infty}$ are well developed, and twins according to ∞ P $\dot{\infty}$ are common. Longitudinal sections with parallel extinction and normal position of the axial plane exhibit very little pleochroism. Strongly pleochroic titanite and pyrite are extraordinarily abundant. In its present condition the rock is best classed as an epidote amphibolite. It has doubtless been derived from a plutonic rock and been impregnated with titanite and pyrite, while scapolite, amphibole and epidote have been derived from feldspar and pyroxene.

The transition into the above-mentioned 'pyroxenite' can be followed microscopically. Quartz and feldspar disappear altogether; conversely colourless pyroxene and phlogopite, in places much whitened, appear in the sections. Scapolite becomes more abundant.

Crystalline Schists from the Apatite Region.

Here again only certain typical rocks will be described.

Squaw Hill mine quartzite.

Quartzite from the Squaw Hill mine.—Quartzites similar to those described from the Montebello section, alternate with gneiss in the neighbourhood of the London, Little Rapids and High Rock mines. They generally contain isolated macroscopic feldspar grains. Upon the dumps of the Squaw Hill mine were found pieces of a quartzite which, under the magnifying glass, showed abundant green pyroxene and isolated grains of titanite. Under the microscope, by far the greater part of the rock is seen to consist of an aggregate of quartz with the same structure as the Montebello quartzite. This aggregate is traversed by strings and veins formed of a mixture of light-green augite, dark-green hornblende, abundant scapolite with its characteristic inclusions, titanite, epidote and some calcite. Plate X., Fig. II., shows

such a portion moderately magnified. On the right and left sides of the the figure is the colourless quartz; through the middle runs such a vein whose contacts with the quartz are very sharply defined. At other places the quartzite mass in the neighbourhood of such veins is interpenetrated with grains of these minerals. This is doubtless another typical example of secondary formation, caused by impregnation with solutions or vapours. Similar relations are observed in the quartzite from the Crown Hill mine.

Formation of apatite connected with alteration of gneiss.

As to how far gneisses in the neighbourhood of the apatite veins have been altered by such impregnations, or how far in particular the content of pyroxene is to be attributed to such causes, it is difficult to say; on the one hand, because pyroxene-bearing gneisses have been found abundantly in other parts of Canada, *e.g.*, by Adams, east of the apatite region; and on the other hand, because of the short time which I could devote to the examination and the lack of good exposures, it was not possible to follow such augite gneisses to any great distance from the apatite veins. But I certainly believe that such alterations are in many cases connected with the formation of the apatite.

Garnet-sillimanite-gneiss.

Garnet-sillimanite-gneiss from Poupore post office.—In the opening already referred to many times, there occur alternating with the 'pyroxenites', gneisses and quartzites. The gneiss strata are cut by pegmatite veins, which consist mainly of feldspar with some quartz. In the neighbourhood of these veins, dislocations and shiftings of the gneiss have taken place. In places the gneiss is completely shattered and cemented by pegmatite. Large pegmatite veins enclose fragments of gneiss, and at the same time off-shoots and apophyses as thick as one's finger have run out between the bands of the latter. The garnet-sillimanite-gneiss forms a band somewhat more than 1 m. thick. It consists of alternate layers rich in light-coloured feldspar and in dark-coloured mica. The light red-garnets, up to 2 mm. in diameter, are distributed irregularly through the rock.

Under the microscope it may be determined that the colourless constituents are essentially feldspar while quartz is distinctly inferior in quantity. Of the feldspars, plagioclase predominates over microcline and unstriated feldspar. Only biotite is present as a dark-coloured constituent. The garnet is of a very light rosy-red colour, and is transparent and optically isotropic. Sillimanite needles are found only in the garnet but literally fill it in places. Rarely there are found in the garnet isotropic grains of dark green colour and stronger refrac-

tion which are probably a spinel, very likely hercynite or pleonast. Rutile, in the form of little crystals and twins, is a relatively abundant constituent.

The structure in sections parallel to the schistosity is perfectly irregular. Feldspar and quartz everywhere exhibit marked signs of pressure, which develope an incipient mortar-structure. Large plagioclases are often crushed; the individual fragments, displaced with respect to one another are still recognizable as belonging to one another. Undulose extinction and the bending and breaking of twinning lamellæ are very common. The biotite exhibits an irregular ragged form. In sections at right angles to the schistosity a parallel structure is developed chiefly by the alternation of layers rich and poor in mica. Quartz and feldspar contribute but little to the parallel structure, a few large quartz grains have been squeezed out in the direction of the schistosity. No regular arrangement of the constituents around the garnet is observable.

In all probability the rock is an altered sediment; the alternation with quartzite and the mineralogical and chemical composition favour this opinion to a certain extent. On account of the abundance of garnet and of a pure alumina silicate, sillimanite, the chemical composition of the rock must vary greatly from that of an eruptive rock.

North of the London mine garnet gneisses seem to be widely distributed. They are somewhat fine-grained rocks, rich in mica, whose structure is more distinctly foliated. Garnet here occurs in isolated lumps "augen" (up to 5 cm. diameter).

Peculiar crystalline schists in London mine.

A series of very curious crystalline schists are found in the upper and lower workings of the London, mine in contact with the veins carrying apatite. They exhibit an alternation of almost snow-white and dark gray layers; the individual layers are often only about a centimeter thick. The white layers consist almost entirely of quartz and feldspar. The grain is fine and extraordinarily uniform; the individual minerals possess the form of rounded grains so that the appearance under the magnifying glass is very similar to that of many aplites or very fine sandstones. In these light-coloured parts there is not a trace of parallel structure. The same is true of portions which on account of the occurrence of hornblende, pyroxene and titanite, are somewhat darker in colour. In the above mentioned perfectly evenly distributed feldspar-quartz aggregate, there are little grains and rods of a light grass-green mineral which under the microscope is

seen to be partly hornblende and partly augite. Little grains of titanite are also present in abundance. Here also there is no sign of a parallel structure, or it is exhibited to a very small extent in a tendency to parallel arrangement of the green minerals. Such portions on account of the rapid alternation of layers and their light colour exhibit a great similarity to granulites. If the darker constituents become more abundant they seem to prefer to collect into bunches; the appearance is then similar to the variety known as "Forellen granulit." The very dark layers are very rich in mica.

Constituents and structure of rocks.

Under the microscope the rocks have a well defined honeycomb structure. The feldspar is mainly orthoclase, a little being microcline and plagioclase. Quartz is much less abundant than the feldspar. The very light-coloured hornblende must belong to the tremolite-actinolite series and is in part crystallographically developed in the prism zone. The augite is almost colourless and transparent. Titanite is very abundant in relatively large pleochroic grains; zircon and apatite are common.

The darker bands are rich in a light green-brown, transparent and feebly pleochroic mica. The light green pyroxene is fibrous on account of a parting parallel to $\infty P \breve{\infty}$. This is of course most clearly seen in sections parallel to the prism zone and the extinction is parallel; the plane of the optic axis lies parallel to this. Hornblende is relatively rare but generally well outlined and often enclosed in augite. Sections at right angles to the c axis exhibit only the prism faces on their outline as is often the case with actinolite. Constituents which are very characteristic for granulite, such as garnet and also cyanite, andalusite, and hypersthene, are here entirely wanting. Microperthitic intergrowths also play a very unimportant part. The rocks are perhaps best designated as granulite gneisses. With regard to their origin, it is almost impossible to make a guess. At any rate, a further study of their distribution and their position with regard to the other gneisses is necessary in order to form any opinion upon this point. Moreover, the question as to whether a part of the pyroxene and amphibole, and particularly the abundant titanite and apatite, are not in some way connected genetically with the apatite veins can only be answered when these rocks have been traced out farther along their strike.

Further study necessary.

Hornblende gneisses containing pyroxene were also met with at the High Rock and North Star mines. Here again it must be left to later investigations to show whether the pyroxene is not in some

way connected with the apatite veins. They are both medium-grained rocks rich in red orthoclase, and the darker constituents predominate in certain layers without actually producing a distinct schistosity. They may be best described as granular-streaky. The lighter layers contain much microcline, and the only dark coloured constituent present is mica which possesses a strong pleochroism between straw-yellow and dark greenish-brown. This mica can be distinguished at a glance from that of the apatite veins. In the darker layers the mica decreases and green hornblende and green-gray pyroxene increase. Both in hand specimens and under the microscope this gneiss is very similar to that described from the neighbourhood of Lachute and probably possesses the same origin.

Eruptive rocks which occur in the neighbourhood of the apatite veins, but which have nothing to do with their formation.

Eruptive rocks near apatite veins.

Along with coarse-grained pegmatites which are widely distributed in the neighbourhood of the apatite-bearing veins, another type of granite veins occurs, which is characterized by a very even medium to fine grain and an almost complete lack of darker constituents; the rocks consist almost entirely of quartz and feldspar which is mainly microcline. Such a vein about 0·5—1 m. thick has been cut into in the upper workings of the London mine. The normal very light coloured rock is here cut by dark gray-green veins, which often exhibit a regular round or elliptical outline. The rock thus has a very peculiar appearance and is known in Canada as 'leopard granite.' Similar masses were found on the dumps of the Little Rapids, North Star, High Rock and Union mines. A very typical block of this leopard granite was shown at the Paris Exhibition, in 1900. Plate V shows a piece from the London mine. With the magnifying glass one easily sees that these veins are caused by an increased quantity of pyroxene, with which in places much pyrite is associated. Under the microscope they consist of light-green pyroxene, dark sap-green hornblende, epidote, very abundant titanite, apatite, and small quantities of carbonates. Apophyses frequently branch off from the larger veins and after a short course thin out. These minerals have penetrated sparingly in the immediate neighbourhood into the mass of the rock itself.

The whole appearance leaves no doubt that one is dealing with secondary structures, which have been formed upon more or less spherical jointing faces. The identity of the minerals occurring here with the essential ones of the apatite veins makes it certain that impregnation has occurred here and that this process is connected with

the formation of the apatite and the minerals accompanying it. It is analagous to the secondary formation of phlogopite on the joint-planes of the gabbro from Murray's pit already described.

Diabase and augite porphyry both occur in the form of veins. In the neighbourhood of the Little Rapids mine two diabase dykes occur, each at least 10–12 m. in thickness, and having a strike almost east and west ; they thus cut the gneisses and quartzites, which here have a strike N.N.E. and S.S.W., almost at right angles. One of these veins is cut by the tramway south of the Little Rapids mine on the slope towards the Lièvre river, and the other north of the main building and the smithy. Both dykes cut not only the gneiss and quartzite but also the pegmatite occurring in them, the northern diabase vein also cuts the pyroxenite, so that they are the youngest dykes in the district. Diabase dykes cutting gneiss.

Both diabases are somewhat coarse-grained, quite fresh, and exhibit macroscopically typical ophitic structure. Under the microscope the plagioclase always exhibits sharply defined forms elongated in the direction of one axis, the interstices being filled with allotriomorphic augite. Not infrequently the latter exhibits for considerabley stretches uniform orientation and is then poikilitically penetrated by the feldspar forms. Sections of the latter normal to P and M gave extinction of 36-38° with the trace of M; the plagioclase belongs therefore to the labradorite series and has approximately the composition Ab_2 An_3. Two such sections with a nearly square outline were observed, which fell into two twin halves along a diagonal. They are probably Baveno twins. The augite is transparent and of a gray-brown colour ; it is a typical diabase augite. Some olivines are completely converted into serpentine. Titanic iron in irregular forms is present in abundance.

An augite porphyrite from the Crown Hill mine is seen in an old opening as a vein 0·5—1 m. thick, cutting pyroxenites and apatite veins. It is a black very fine-grained unaltered rock without any phenocrysts. Under the microscope the feldspars are distinguished from the other constituents by somewhat greater dimensions; they are lath-shaped, but without well defined straight outlines. Between them is a fine-grained mixture of augite grains partially uralitised, some brown mica, ore grains and a very little quartz. Augite porphyrite.

A somewhat different structure is exhibited by an augite porphyrite which forms a vein in the gneiss about 0·5 m. thick with a strike east and west, north of the London mine. The groundmass of this black

and almost compact rock has a distinct intersertal structure. In it there are large nodules made up of a collection of irregular augite grains with scattered feldspar particles.

Evidently these diabases and augite porphyrites belong to one and the same younger dyke formation; the thicker dykes are made up of diabases, the thinner of augite porphyrites. The eruption to which they belong occurred after the formation of the apatite veins, and the occurrence of the latter does not stand in any genetic relation to them.

Results of investigations.

The results which have been attained by the examination of the apatite occurrences of the province of Quebec, may be summed up briefly as follows :—

1. The apatite always occurs in true veins, which cut the Laurentian gneisses and associated beds, as well as the so-called 'pyroxenites'. In the first case they are developed in part as bedded veins, i.e, correspond in strike and dip with the neighbouring rocks, in part they cut these rocks at right angles. No reasons whatever have been found for considering these apatite deposits as an integral part of the Laurentian gneiss formation of the same age.

2. The apatite-bearing veins are accompanied by basic plutonic rocks (silica, about 48·50 per cent) which belong to the families of the gabbros, shonkinites, and in part pyroxenites. The 'pyroxenites' of Sterry Hunt are in part such plutonic rocks in an altered condition, in part secondary formations in the veins themselves.

3. The essential alterations which the plutonic rocks have undergone consist in a secondary formation of scapolite (at the expense of the lime soda feldspars), of mica (phlogopite), titanite and sulphides (pyrite, pyrrhotite, and in part chalcopyrite).

4. There is indubitable evidence that the gneisses, quartzites, vein granites and other associated rocks have been impregnated with material from the veins, and that in this way secondary developments of augite, among the minerals mentioned under 3, have been brought about. This process is particularly clearly seen where these secondary developments have been limited to the cracks and crevices of the adjoining rock. The pyroxene of the neighbouring gneisses is perhaps also to be referred to such a cause.

Associated vein minerals.

5. In the veins, a distinct association of minerals is observed. Part of them are distinguished by their containing fluorite or chlorine; to these above all belong apatite, phlogopite, scapolite and tourmaline;

of less importance is, curiously enough, fluorine. Then sulphides are abundant, especially sulphides of iron, pyrite and pyrrhotite, and of less importance, chalcopyrite. Of minerals containing titanium, titanite is abundant, while rutile has not been recognized with certainty. Then a series of pure silicates, especially pyroxene, and less abundantly amphibole and feldspars. Finally, in very large quantities, calcite, which, according to my experience, is always the youngest of the vein minerals. Quartz is rarely found. The occurrence of graphite in several cases mentioned by Harrington, is of great interest from a theoretical standpoint.

Characteristic ore vein structures of apatite.

6. The apatite veins show in some places structures which in the case of ore veins are generally considered characteristic, among them lateral symmetrical structure, cockade structure, and drusy cavities.

These facts show that an extraordinary resemblance exists between the Canadian apatite veins and those of southern Norway, the mode of occurrence of which latter have been described by Brögger, Reusch[24], and recently in great detail by Vogt[33]. There is found the same connection with basic plutonic rocks (gabbros, olivine hyperites, etc.), the same extension of the veins into the neighbouring schists and limestones, 'mostly as bedded veins,' (Vogt) and an association of minerals almost identical with our own if we omit certain unessential points. In Norway the presence of titanic acid has brought about the formation of rutile, here of titanite; in Norway the secondary pyroxene is predominatingly the magnesiarich enstatite, here diopside and malakolite rich in lime; in Norway minerals containing chlorine play an important part, in Canada, on the contrary, those containing fluorine replace them. On all these points Vogt has dwelt at length. When further Vogt says: 'The most important difference is to be found in the fact that in Norway in the case of the apatite veins occurring in olivine hyperite there is a constant alteration of the country rock into scapolite hornblende rock, and into other scapolitised gabbros, while in Canada this has been only exceptionally observed,' it is clear from what has been said above that in this respect also the most far-reaching correspondence exists in both regions.

Apatite veins in Sweden similar to Canadian occurrences.

Also in the most northerly part of Sweden, in the province of Norbotten, the apatite veins which have been discovered during the last few years correspond in mineral content (apatite, mica, augite, scapolite, tourmaline, hornblende, titanite, etc.), in their connection with basic plutonic rocks (gabbros and olivine hyperites) exactly with the Norwegian and Canadian occurrences. Here further the same action upon the neighbouring rock, the same scapolitisation, has been exerted

(the 'pneumatolitic metamorphism' of Brögger). Vogt states indeed that the discovery of the scapolite in the altered hyperite by Brögger was the cause which led to the discovery of the apatite.

Origin of apatite veins.

In answering the question as to the origin of the apatite veins, one can safely concur in the view put forth by Brögger, Reusch and Vogt, and for the Canadian occurrences in general outlined by Ells (see References) that the formation of the vein minerals has been caused by a fumarole process which accompanied the eruption of the basic magmas or directly followed it. The material from which the veins were formed, particularly the abundant elements Cl, F, Ti, P, B (in tourmaline), Li (in phlogopite) and sulphur cannot be considered as derived in any way by lateral secretion from the neighbouring gneisses. All the circumstances point to the view that they came up from below and that this phenomenon was connected with the ascent of the basic magmas. Vogt points out rightly the broad chemical and geological analogies between these apatite veins and the tin ore veins.

On the Eozoon Limestone of Côte St. Pierre.

Eozoon limestone.

From Papineauville station (on the line of the Canadian Pacific Railway between Ottawa and Montreal) an excursion was made to Côte St. Pierre, lying about ten miles north, from which place, as is well known, Logan described some of the first specimens of Eozoon Canadense. The exposures examined were on the south-east steep side of a thickly-wooded hill and consist of an old quarry, which was made for the purpose of obtaining serpentine asbestus, and is now abandoned, and several small openings made for the purpose of obtaining Eozoon.

The main rock of which the hill consists is a coarse grained plutonic rock without any indication of parallel structure, rich in dark constituents, mica and pyroxene. The feldspar is seen by the naked eye to be plagioclase, on account of the twinning striæ. In accord-

Fig. 11. Eozoon Canadense.

ance with the analysis given later, the rock is best designated as mica-hypersthene-gabbro. The main steep slope of the hill is succeeded by a flatter portion, and in this the contact between the gabbro and the Eozoon limestone lies. There are almost no openings here. There then follows a somewhat steeper portion where the best specimens of Eozoon were found and where the former asbestus mine was situated.

Description of contact rock.

The mica-hypersthene-gabbro is, as already stated, coarse-grained (grains 4-5 mm. in diam.) and shows macroscopically brownish coloured quite unaltered plagioclase, generally in the form of short broad laths, on which account the structure reminds one of that of diabase, abundant black mica and dark pyroxene partly with a bronzey lustre, which is shown by the microscope to be partly rhombic and partly monoclinic. These pyroxenes have lost their lustre along their edges on account of the formation of uralite.

Under the microscope the plagioclase exhibits the usual twinning lamellae according to the albite and, in part, pericline law. It contains many inclusions, as is so frequently the case in basic eruptive rocks, in the form of a fine dust, which, with a high power, is resolved into tiny rods and plates; the latter have hexagonal outlines and are transparent and of a gray-brown colour; they are probably titanic iron. The extinction angle was measured on plates parallel to OP and found to be 2-4½°, on plates parallel to $\infty P \breve{\infty}$, 12-16°; a determination of specific gravity with the picnometer gave 2·675. It is, therefore, a feldspar belonging to the oligoclase andesine series; the specific gravity corresponds very nearly to a mixture Ab_2 An, and the extinction angle to a somewhat more basic one. Probably on account of the freshness of the mineral, the specific gravity is a better guide than the few extinction angles.

The monoclinic pyroxene is trasparent and of a light green-gray colour, and exhibits almost no pleochroism. In sections parallel to $\infty P \breve{\infty}$ the extinction $\mathfrak{C} : c$ was 42°. Beside the normal cleavage parallel to ∞P there was one parallel to $\infty P \frac{1}{\infty}$ with few cracks but strong and running straight, and a great many short but sharp cracks parallel to $\infty P \breve{\infty}$ causing a fine fibrous structure. These relations are best observed, especially the regular intergrowth with the rhombic pyroxene on sections at right angles to c. The central portion of such a section is formed of rhombic pyroxene with distinct pleochroism between reddish and almost colourless. Beside the cleavage parallel to ∞P there is present a system of fine cracks; the ray undulating parallel to them is reddish in color; in convergent light a bisectrix appears almost normal; the plane of the optic axes is parallel to these fine

cracks. It is therefore the cleavage parallel to $\infty P \breve{\infty}$ so common in rhombic pyroxenes. The peripheral portion of the section is composed of augite. In convergent light one axis appears at the edge of the field, the plane of the optic axis is parallel to the above mentioned fibrous cracks, the latter being normal to the cracks parallel to $\infty P \breve{\infty}$ of the rhombic pyroxene. Hence the fibrous cleavage of the augite is parallel to $\infty P \breve{\infty}$. In the same section both pyroxenes pass over into uralite which forms the outer edges and numerous irregularly distributed patches in the interior. All three minerals exhibit simultaneous extinction. The rhombic pyroxene always seems to be older than the monoclinic. Both, especially the former, contain inclusions of little rods and plates similar to those in the plagioclase. The green hornblende, in spite of the fact that it is often quite compact, is in all probability wholly derived from the pyroxenes. It exhibits the usual pleochroism, a light yellow-green, b and c dark grass-green.

The mica collects into bunches with the above mentioned dark constituents, and is mostly certainly primary. A small part seems to have been derived from the uralite.

The dark constituents are irregularly outlined, only the rhombic augite exhibits in part rough prismatic forms, it is undoubtedly the oldest of all.

Besides apatite and isolated metallic grains, there is some quartz in very small grains between the feldspars. Pressure phenomena are hardly present.

An analysis by Dr. Dittrich gave the composition under I; under II the corresponding molecular proportions have been calculated to 100, leaving out the H_2O and CO_2.

SiO_2	52·19	55·92
TiO_2	0·72	0·58
Al_2O_3	14·52	9·15
Fe_2O_3	3·19	8·10 FeO
FeO	6·21	
MnO	trace.	
MgO	6·57	10·56
CaO	8·88	10·20
Na_2O	3·65	3·79
K_2O	1·53	1·05
P_2O_5	1·43	0·65
H_2O	0·53	
CO_2	0·66	
	100·08	

From II may be calculated :

$A = 4 \cdot 84$; $C = 4 \cdot 31$; $F = 24 \cdot 55$; $a = 3$; $c = 2 \cdot 5$; $f = 14 \cdot 5$ $n = 7 \cdot 8$ and the formula :

$$\overline{s}_{56.5}\ \overline{}\ a_2\ \overline{c}_{2.5}\ f_{14.5}\ \overline{n}_{7.8}$$

A glance at the table of plutonic rocks (2) shows that the rock holds about the same position as the mica gabbro from Hurrican Ridge, Yellowstone Park, described by Iddings, and that the mineralogical constitution of both rocks is very similar. The latter contains augite, hypersthene, biotite, plagioclase, some orthoclase, quartz, and olivine. The position of the Canadian rock on the limit of the gabbro and diorite table is also exactly the same. It is best placed in the first vertical series of the gabbros as a type above Molkenhaus (under $a = 3$). In the diorite table, on account of its a c f ratio it would fit in between the types Montrose and Campo major ; for this position its percentage of silica is a little low. It is therefore designated as mica-hypersthene-gabbro. It is also chemically very similar to the essexite type, Fairview ; here, however, the proportion of alkalies is in general somewhat higher, the value for f distinctly lower. The type point in table VIII (loc. cit.) comes near the points 36 (Montrose) and 67 (Cabo Frio). From the numbers for A and C we obtain an average plagioclase $Ao_{9 \cdot 6}\ An_{4 \cdot 3}$. The value for Ab is undoubtedly, on account of the considerable quantity of mica, somewhat high, and in spite of this the value varies but little from that calculated from the specific gravity.

Mica-hypersthene gabbro.

A comparison with the gabbro from Murray's pit shows that the rock from Côte St. Pierre is somewhat more acidic and correspondingly richer in alkalies and alumina, but poorer in bivalent metals ; especially the quantity of magnesia, in spite of the mica content, is distinctly lower. Murray's pit is lower and more to the right in the gabbro table.

In this normal coarse-grained plutonic rock occur abundantly distributed streaky and vein-like masses which are of a very uniform, distinctly finer-grain and without any porphyritic secretions whatever. Under the microscope, they are found to differ from the main rock essentially as follows :—

1. The rhombic pyroxene is entirely absent ; at least in the several sections examined its presence could not be determined.

2. The dark mica is somewhat more abundant and about equal in quantity to the augite.

3. Quartz, although still scarce, is more plentiful than in the main rock; further, some orthoclase seems to be present along with the plagioclase.

The structure strongly resembles that of many malchite dyke rocks.

Structure similar to malchite dyke rocks.

Two hand specimens were collected from the 'gneiss portions' on the other side of the road. Both are distinctly more fine-grained than the normal gabbro. One of them is rich in dark-coloured constituents and is similar to a fine-grained gabbro or diorite. The other is somewhat lighter; the feldspar is partly coloured reddish; the mica is arranged in parallel layers, so that there is a gneiss-like appearance. From external characters one would designate the rock as a syenite gneiss. Under the microscope, both rocks contain plagioclase in relatively large regularly outlined grains, with the above mentioned inclusions. Between these plagioclase grains lies a fine-grained irregularly distributed aggregate of unstriated feldspar and quartz. The first contains along with mica abundant monoclinic augite, which is partially uralitized; in the latter, no unaltered augite has been observed, but part of the green hornblende may be uralite. It is also rich in apatite and titanite.

The former seems to me undoubtedly to be a marginal facies of the gabbro, but I am not sure of this. A decision can be made only after a further study of the field relations.

Direct contact not exposed.

As has already been stated, the direct contact between the limestone and the gabbro, b on the profile, is not exposed, but in many places it was possible to uncover rocks which undoubtedly came from very close by it. It is characteristic of the specimens thus collected that feldspar and quartz were completely wanting, and that their coarseness and composition varied very much at points but a little distance apart. One of them is exceedingly tough, fine-grained, of dark greenish-brown colour, and in which may be detected macroscopically isolated large plates of mica and cleavage surfaces of green hornblende up to a centimetre across, irregularly outlined and interpenetrated poikilitically by other minerals. Under the microscope, the main mass of the rock is seen to consist of light-gray transparent augite and green faintly weakly pleochroitic hornblende. Mica is only rarely present, and there is also some calcite, a green transparent spinel and abundant titanite. Feldspars and quartz are altogether absent. The hornblende is very irregularly distributed; in certain portions of the section it forms large shreds which are poikilitically penetrated by other minerals. Where it is wanting, the structure is that of a typical lime silicate

hornstone of relatively coarse grain. Plate VIII., fig. 2 gives a representation of this structure.

Another one of these rocks is distinguished by the fact that, macroscopically, besides green pyroxene and very abundant titanite, it contains large grains of a white mineral that, in lustre and cleavage, is similar to the scapolite of the apatite veins. Mica is also very abundant in spots. Under the microscope, this undoubted contact product consists in part of a very uniform mixture of pyroxene, scapolite and titanite. Plate XI., fig. 3, is taken from such a place. Other parts of the same section are made up almost entirely of scapolite, which is coarsely fibrous, the individual fibres having a tendency to arrange themselves radially. Plate XI, Fig. 4.

Massive serpentine from near contact.

From still another place in the neighbourhood of the contact comes a black-green massive serpentine, cut by cracks a centimetre wide, filled with some calcite and large mica crystals. Under the microscop., the serpentine exhibits in some places distinct cross-hatching, caus·d by two fibrous systems crossing one another at right angles. Thei·e are isolated grains of carbonates and mica plates in the serpentine. The mica which fills the cracks has an axial angle of about 30°, and is filled with red-brown inclusions.

At another point near the contact is a very coarse diopside rock. The whole rock consists of coarsely crystalline grains of 2–3 cm. diameter of a light green to almost colourless diopside.

Limestone exhibiting contact metamorphism.

I obtained some hand specimens from Prof. Schmidt in Basel, who had collected them on a former excursion to this place, and which consist of about equal quantities of diopside and calcite. The latter forms a coarsely crystalline marble, in which the diopside is developed as very well formed crystals over a centimetre long. The crystals are short prisms, the two vertical pinacoids occur only as narrow truncations of the prism edges. The terminations consist of OP and various pyramids. The latter are usually very rough and unsuitable for measurements, while the faces of the prism zone and OP give very good reflections. All crystals exhibit a perfect parting parallel to OP probably on account of a fine twinning. The extinction angle in one section parallel to ∞ P ∞, determined with Na light, was 37°.

Undoubtedly we have here a limestone exhibiting contact metamorp sm; the whole paragenesis of minerals, the great variety in the g·ain of the rocks in such a short distance, and the typical contact structure are extraordinarily characteristic. At a somewhat greater

distance from the contact the carbonates still prevail, in them the diopside has developed in the form of crystals, and irregular concretionary masses, or with the structure peculiar to Eozoon. Dawson says 'sometimes (not usually) pyroxene is the silicious part of Eozoon.' The diopside is very frequently altered to serpentine. When Dawson says 'Further the white pyroxene of the Laurentian limestones and the loganite and dolomite are all known to have been produced by aqueous deposition,' it certainly does not apply to the augite here; it is in this place a product of contact metamorphism. The normal granular limestones of Canada also very often contain green pyroxene, as has already been pointed out. The rocks here described cannot, however, be mistaken for them; they are recognized as different upon the first glance.

Origin of Eozoon.

With regard to the question as to the organic origin of Eozoon, this is in no way connected with the above facts and their explanation. If Eozoon was an organic being, its hard parts which are still preserved certainly did not consist originally of diopside or serpentine but were first converted to the former by an act of metamorphosis. It may here be pointed out that Johnston-Lavis and Gregory[35] have recently obtained pieces of lime silicate, ejections from Monte Somma, in which the typical structure of Eozoon is present. According to these two authors, this structure is not originally organic, but is produced by metamorphosis. In the Monte Somma specimens augite is subordinate to the basic lime and magnesia silicates olivine and monticellite; there also occur mica and spinels, as is the case at Côte St. Pierre.

TWO CANADIAN OCCURRENCES OF GRAPHITE.

I. *On the occurrence of Graphite at Graphite City, Township of Buckingham.*

Occurrence of graphite widespread.

According to the older reports of the Geological Survey, of which I have been unable to make a through study the occurrence of graphite in Buckingham and the adjoining townships is very widespread. In the first township it is reported from many points in lots 18—28 and ranges V—VIII. In most cases work seems to have been confined to small openings, in only a few has the graphite actually been worked, and even here this has been done very sporadically and with long delays intervening. In this whole area, as far as is known to me, work is carried on only at Graphite City, and there on a small scale.

In the Report for 1873–74 Mr. Vennor has given some information with respect to the way in which the graphite occurs, and according to this the mineral is found 'in three distinct forms :

1. As disseminated scales or plates in the limestones, gneisses, pyroxenites and quartzites, and even in some of the iron ores, as at Hull.

2. As lenticular or disseminated masses embedded in the limestone, or at the junction of these and the adjoining gneiss and pyroxenite.

3. In the form of true fissure veins cutting the inclosed strata.'

Walker Mining Co.

The workings of Walker Mining Co. lie in lots 19, 20, 21, 22, ranges VII and VIII. There are about 30 openings where graphite has been found, of which several generally lie more or less in a group, they however stretch over a large area, which, on account of the woods and in many places the swamps, is difficult of access. Only in two places does the work seem to have progressed beyond the most primitive stages, at the Main pit where a moderate work is being carried on, and at a group of pits west from this, along the boundary of lots 21 and 22, ranges VII and VIII. Here there are ten pits altogether, of which the largest one is known as Nelly's pit. During the seventies, graphite was mined in considerable quantity by the Dominion of Canada Plumbago Co., as can be seen from the depth of the working and the dumps. What is given below refers for the most part to these two localities. Only a few other openings were visited ; many were vainly looked for in the thick woods. On this account, and the short time of my stay, my observations must necessarily be of a very fragmentary character.

Of special interest are the following points :—

Graphite occurs as filling of veins.

1. In all the pits I have seen, with but one exception which will be mentioned later, the graphite occurs as the filling of veins and cracks in gneiss, granular limestone, pegmatite, and granular eruptive rocks. The direction of these veins is independent of the strike of the rocks traversed. Thus in a small opening between the Main pit and Nelly's pit the gneiss has a strike N. 70° E. and a relatively flat dip. It is cut by four graphite veins all parallel and about 4—5 cm. thick, whose strike is N. 20° W. and dip almost perpendicular. Near Nelly's pit there is a pegmatite vein in the gneiss several meters thick. In this, in a relatively small space, there are several graphite veins which have been exposed in openings, and which are as broad as one's hand in places but usually only a few centimetres. In Nelly's pit itself the veins are collected on the boundaries of the granular limestone, the gneiss and a plutonic rock, which, as far as one can see, forms a large dike. Some of these veins have a thickness of over 20 cm. One

can see very well from the abundant material on the dumps how narrow apophyses and branches have run out from the large graphite veins between the layers of gneiss, how these dwindle away, and how along their line of continuation isolated plates and knobs of graphite are deposited. See Plate VII. The granular limestone is strongly impregnated with graphite from the veins. One gets the impression that the loose structure would make the penetration of a foreign substance particularly easy.

Exception to vein formation at Main pit.

The one apparent exception to this vein formation of the graphite is found at the Main pit itself. This is a horizontal tunnel-like working about 20 paces long and on the boundary of the granular limestone and the gneiss. I could not find any graphite veins here, but both rocks are abundantly and very uniformly impregnated with little graphite plates. An opening made about 50 paces above this working in the same hill-side shows a graphite vein about as wide as one's hand on the boundary of the gneiss and granular limestone which is here peculiarly altered (see later).

The complete similarity of these relations shows that the graphite is here a typical vein mineral, that the veins are younger than the pegmatite, and therefore certainly younger than the gneiss and granular limestone cut by the pegmatite. The occurrence at Main pit is really no exception. Here the graphite and even the carbon is no original constituent of the gneiss and limestone but a later impregnation which has proceeded from the graphite veins and which is most closely connected with them.

Mineral content of graphite veins simple.

2. The mineral content of these graphite veins is always very simple, in by far the larger number of cases the graphite itself filling the veins ; it then consists usually of parallel fibrous or rod-like aggregates, the direction of the fibres being normal to the walls of the vein, as is very common in Ceylon and in other places. Plate VI shows such a fibrous graphite vein, about two fingers thick, in pegmatite. In rare cases green apatite and scapolite occur with the graphite. Thus, I found near Nelly's pit vein-fragments which contained pieces of pure apatite up to the size of one's fist, while the main mass consisted of a granular aggregate of apatite-quartz, very abundant titanite, graphite, scapolite and pyroxene. Many sections of this aggregate cannot be distinguished in any way from the 'pyroxenite' of the apatite veins. Mr. Walker, the owner of the mines, told me that large pyroxene crystals had been found directly upon the selvage of a vein. The occurrence of apatite appears to be not uncommon, and reminds one of the occurrence of the same mineral on the graphite veins in Ceylon. Thus, Sandberger[3 6]

found in a lump of graphite from there a core of olive-green apatite as big as an apple, also very abundantly rutile, some titanic iron, feldspar, quartz, a light brown-mica, and sulphides, particularly pyrite. According to the analyses of Jannasch and Locke, this apatite is very rich in fluorine. Grünling[37] describes the occurrence of apatite in graphite in Ceylon in the form of large crystals along with iron-magnesia mica, calcite, quartz and pyrite. Weinschenk[38] mentions also unusually large pyroxenes (ordinary green augite). Coarsely crystalline calcite also plays an important role in the Ceylon veins.

Eruptive rocks at Graphite City similar to those with apatite occurrence.

3. The occurrence of graphite at Graphite City is connected with the appearance of massive eruptive rocks which in mineralogical composition are very similar to those described in connection with the apatite occurrences. One might in part repeat the description here. By Mr. Walker's house there are little cliffs consisting of alternate bands of a dark and light gneiss-like rock—it is a hypersthene biotite gabbro. Similar, though more altered, plutonic rocks consisting essentially of plagioclase, augite, and mica occur at the Main pit and Nelly's pit. Whether they are parts of a large mass or are unrelated could not be determined from the poor exposures. The hand specimens from the two last mentioned localities do not show any evidence of parallel structure and are similar enough to be mistaken for one another.

As far as I could see on my short visit, the occurrence of the graphite is connected with the contact of this eruptive rock with gneiss and granular limestone. The limestone is in these places very much altered; there has been especially a large production of scapolite, pyroxene and titanite. Such altered limestones are so like the scapolite pyroxene rock from the neighbourhood of the apatite veins as to be mistaken for it.

Of the rocks from the neighbourhood of the graphite veins, the eruptive rocks will be now described.

Hypersthene biotite gabbro.

Hypersthene biotite gabbro from the neighbourhood of Walker's house. This rock, as already pointed out, has macroscopically a gneiss-like appearance; microscopically there are seen very strongly developed signs of pressure passing into rudimentary mortar structure. Particularly the feldspar, which is almost entirely plagioclase, exhibits undulose extinction, bending and breaking of twins, and similar pressure phenomena in a wonderfully beautiful manner. Along with a monoclinic augite is less abundantly a strongly pleochroic hypersthene. Both are allotriomorphic, the hypersthene in great part converted into a green alteration product. The monoclinic very faintly pleochroic

augite shows in sections at right angles to c along with the prismatic cleavages, short sharp cracks which are visible only by considerable magnification and very good lighting, and which correspond to the orthopinacoid; the plane of the optic axes is normal to them. Mica is also abundant. The rock must come very close chemically to that from Côte St. Pierre as it does mineralogically, only it is distinctly finer grained.

Another similar rock above Main pit.

A rock which I found above the Main pit in large blocks near the graphite vein already described and which must occur very close by, is very similar to the one just described. The rhombic pyroxene is here much less abundant. Of light-coloured constituents, besides plagioclase, a microperthite is very abundant and also some quartz. The structure is completely irregular and that of a normal plutonic rock. Pressure phenomena are less distinct.

A few paces north of the entrance of the Main pit the same rock occurs again. Macroscopically, it cannot be distinguished from the one last described. Under the microscope, it exhibits very peculiar appearances. Here again by far the greater part of the feldspar is plagioclase. This plagioclase is completely intergrown with quartz. All those phenomena described as *quarz de corrosion*, *quarz vermicule*, &c., may here be studied in peculiar beauty. From the edges of the feldspar sections there run inwards tube and worm-like developments of quartz which frequently unite and form a regular network. Fig. 2, plate XI., shows a typical example of this latter variety; the isolated plagioclase particles are much rounded, as though roughly broken up and in part somewhat displaced with regard to one another. In other sections the plagioclase has a sieve-like appearance, caused by numerous inclusions of quartz, generally irregularly outlined but frequently similarly oriented optically. In other cases these quartz inclusions are long and spindle shaped, and are then arranged parallel to one another and to the twinning lamellæ of the albite. Not infrequently, the quartz is replaced by a very fine granophyric intergrowth of feldspar (orthoclase ?) and quartz. Fig. 1, plate XI., shows a place where such an aggregate has eaten its way like a tube into a large plagioclase and which ends at its point in pure quartz. Bäckström* has described and figured very similar appearances in inclusions in Scandinavian diabase, and called them corrosion phenomena. Such an explanation is also applicable here. The occurrence of the dark-coloured constituents is also peculiar. The pyroxene is almost completely urali-

Quartz replaced by intergrowth of feldspar and quartz.

* H. Bäckström: Über fremde Gesteinseinschlüsse in einigen Skandinavisches Diabasen, Medel f. Stockholms, Högskola, Nso. 108, 1890.

tized ; it is eaten away and filled with little mica plates and particles of quartz, similarly to what was observed in the scapolitized gabbro from the Vavasour mine. The brown mica never forms large plates, but invariably a lot of little spangles and irregularly bounded knobs which group themselves radially, preferably about the pyroxenes and metallic minerals or are arranged in parallel swarms. In a short distance such a group of parallel-arranged micas break up into a sort of soot, so that its arrangement looks like that of the microlites having a fluidal arrangement in glassy rocks. Apatite is not an abundant accessory constituent. Lacroix[22] describes and figures very similar conditions in amphibole pyroxene gneisses from the graphite district of Ceylon and from Salem. It is possible that these corrosion and alteration phenomena are connected with the formation of the graphite veins.

Gniess near Main pit contains little graphite.

The gneiss which occurs a few paces from the Main pit contains but little graphite. It is a thinly-bedded rock whose cross section is seen to be essentially a granular mixture of reddish feldspar and quartz with some graphite. Mica is much less abundant. On the principal fracture are mainly small plates of light-brown mica.

Under the microscope, the rock consists principally of an allotriomorphic mixture of unstriated feldspar with a little quartz. Plagioclase seems to be extraordinarily scarce. The feldspars are filled with the same hair and needle-like microlites as were described under the gabbro from South March. They are fairly strongly double refracting and have parallel extinction. Whether they are rutile or not cannot be at present decided. They are certainly secondary ; they are sometimes arranged in regular systems for long distances, similar to the needle-like inclusions in the phlogopite ; in polarized light, it is seen that one such system includes several feldspar grains arranged quite irregularly with respect to one another, and that some of the longer of the needles stretch unbroken and undisturbed through several such feldspar grains.

Mica and graphite about equal in hand specimens.

The dark-coloured constituents are represented only by mica, and not very abundantly. All the parallel structure of the rock is brought about by the parallel arrangement of the mica which is collected into certain planes, the bands rich in feldspar are irregularly granular.

In the portions rich in mica, and frequently intimately intergrown with it, there occurs graphite, and in the hand specimens examined these two minerals are about equal in quantity. The graphite forms irregularly bounded ragged masses usually elongated in the direction

of the schistosity, and, examined in reflected light, is seen to be intimately associated with sulphides, probably pyrite. The same association is found everywhere in the limestone rich in graphite, which is here mined for graphite. The larger particles of graphite exhibit in reflected light irregularly bounded, often elongated portions rich in sulphides and yellow in colour, while the other portions have the lead-grey colour and lustre of graphite.

The graphite often lies in the form of thin lamellæ in the cleavage of the mica, suggesting primary intergrowth, and surrounds it upon the edges. Again, it is seen along transverse cracks and fissures in the mineral, particularly the spaces caused by the mica crystals opening up along the cleavage lines under mechanical stress are filled by it. Portions poor in mica are avoided by the graphite, but it is sometimes seen here and there invariably on the edges of various feldspar grains in long narrow shreds; it follows all the bends and curves of the outline. This whole method of occurrence of the mica shows that it is the youngest of all the constituents and formed in the rock after its solidification, that it is the product of infiltration.

Mica, the youngest constituent.

The parts of the rock rich in mica are the weakest portions, and along them the rock breaks most easily. The portions poor in mica show, as has already been said, an almost irregular and compact structure. Hence along the former an infiltration of foreign matter would take place more easily and in greater quantity. In the portions rich in mica, the mica itself is the mineral which, on account of its good cleavage and elasticity, would most easily be impregnated with foreign substances. These relations are very beautifully shown in Plate IX.

In those portions of the rocks rich in mica and very often enclosed in mica itself, rutile occurs in small needles and twins. Besides, a mineral was observed in somewhat larger grains and crystals, the latter showing quadratic or orthozonal outlines. It shows a very high refractive index, high double refraction and a brown colour; according to its optical properties it belongs to the tetragonal system and was supposed to be cassiterite. In order to make sure the following test was made: The heaviest constituents of the rock were isolated by heavy solutions and several times treated with hydrofluoric acid; a small quantity of a black powder was obtained. It was dissolved in a borax bead coloured slightly blue by CuO; the bead assumed a ruby colour or became opaque, resembling red sealing wax. This very characteristic reaction proved beyond a doubt, that SnO^2 was present. So that though possibly occuring only sparingly, there can be no doubt as to the presence of cassiterite in this gneiss.

Oxide of tin.

The masses employed for obtaining graphite from the main site do not exhibit macroscopically anything but graphite. Under the microscope they are found to contain abundant calcite in large much twined grains, abundant monoclinic augite in irregularly outlined grains partly passing over into a dirty green serpentine-like alteration product, further quartz grains, abundant titanite with strong pleochroism and a colourless mineral in radiating fibrous aggregates that could not be exactly determined but is perhaps tremolite or wollastonite. The graphite occurs as in the above described gneiss in irregularly outlined much elongated lumps. Its intergrowth with pyrite has already been mentioned. As shown by their composition and by the fact that the transition can be followed, these masses have been derived from the granular limestone.

Occurrence of scapolite at contact of graphite veins.

It has already been mentioned that there has been a developement of scapolite at the contact of these graphite veins, and partly upon them. Two of such rocks may here be mentioned. The first comes directly from the contact with the graphite vein which has been opened about 50 paces above the Main pit. It is medium to fine-grained with pyrite abundantly scattered through it and under the magnifying glass has the greatest similarity to contact metamorphosed lime-silicate rock; its structure is quite irregular and granular. Under the microscope it consists of about equal parts of colourless pyroxene and scapolite which in part has undergone the alteration described above. Apatite in large grains and titanite are relatively abundant; quartz is scarce.

The hand specimen of the other rock, also indistinguishable macroscopically from a coarse-grained lime-silicate hornstone, and cut by graphite veins, comes from Nelly's pit. Here too the principal constituents are augite and scapolite, with microcline and a little red brown mica. None of the constituents exhibit crystalline form. The structure is irregular granular, in part distinctly honeycombed.

II.—*On an occurrence of Graphite in Grenville Township.*

Graphite in Grenville Township.

This graphite mine lies about two miles north of the Grenville railway station. On the geological map accompanying a 'Report on the Geology of a portion of the Laurentian area lying to the North of the Island of Montreal,' (Annual Report Geol. Surv. Can,, Part J. Vol. VII. (N. S.) there is in the south-west corner a large syenite area covering about thirty-six square miles in the townships of Grenville, Chatham and Wentworth. According to Ells, the graphite mine lies about one mile west of this syenite just at the limit of the map. A glance at

the map shows that the Laurentian gneiss at this place contains a series of bands of granular limestone, and the graphite mine is in the granular limestone.

First mention of graphite in Geological Survey reports.

In 1845-46 graphite from the granular limestone of Grenville was mentioned by Logan in the Report of the Geological Survey. The graphite was said to occur on lot 10, range V., together with feldspar, quartz, pyroxene and titanite in a vein which cut the granular limestone. Other occurrences were known at various points in this and the neighbouring townships. The occurrence on lot 10, range V. was worked and abandoned at various times. In the Catalogue of the Collection of Economic Minerals of Canada prepared for the Exhibition in Philadelphia, 1876, it is referred to as follows: 'On this lot five beds or veins of more or less pure graphite occur in a belt varying from five to eight feet in width. They range from five to twenty-two inches in thickness and are inclosed in a gangue from which the graphite may be readily separated. This gangue consists of pyroxene, wollastonite, feldspar and quartz with smaller quantities of sphene, phlogopite, zircon, garnet and idocrase. The country rock consists of white limestone. The deposit has been opened to a depth of thirty feet along sixty feet of its course and some of the graphite has been exported, etc. Some of the blocks broken up for shipping were estimated to weigh from 700 to 1,500 lbs.' Recently work seems to have been taken up again actively. At the time of my visit new buildings were being put up and new stamps were being introduced. The whole of the work is carried on in open cuts.

Mode of occurence.

As can be seen from the foregoing description, the graphite occurs filling fissures, *i.e.* as veins in the granular limestone. With respect to the extent of the latter and eventual interbedding with gneisses and quartzites I know nothing. The mine is situated in the thick woods.

The normal granular limestone from an experimental pit is a medium-grained rock which exhibits macroscopically along with a snow-white calcite, rounded grains of a green pyroxene which look almost as though they had been fused, and some graphite in small plates of about 1 mm. diameter. These two minerals are locally concentrated into individual bands of the limestone, causing an alternation of lighter and darker bands. These are indeed the two accessory constituents which are most widely distributed in the granular limestones of Canada. Under the microscope it is further seen that feldspar and quartz are present in spots in no very small quantities, and moreover some colourless transparent garnet and titanite must be mentioned.

For comparison with this limestone, a large quantity of the granular limestone from Lachute Station about ten miles east of Grenville, was dissolved in dilute hydrochloric acid. The limestone is distinctly coarser grained and contains along with pyroxene a light red-brown phlogopite, also some graphite, and a red-brown mineral not further investigated, which looked like garnet but was strongly doubly refracting; possibly it is a member of the humite-chondrodite series. Upon dissolving this limestone there frequently remains a coherent skeleton which consists of abundant quartz and a triclinic feldspar along with the minerals already named. All possess a more or less rounded surface as though fused. The feldspar exhibits polysynthetic twinning lamellæ, and on cleavage surfaces parallel to oP almost parallel extinction, so that it must be an oligoclase. Thus, the normal limestone from the Grenville graphite mines shows no unusual composition.

Vein graphite of economic value.

The graphite which is worth mining occurs in the limestone as undoubted filling of fissures and veins, which occur together locally with almost parallel strike. Few of these veins are more than 1 decim. in thickness. The limestone between the graphite veins is very much altered, and particularly rich in quartz. This forms grains of over 2 mm. diameter, and becomes in places so abundant as to impart to the rock the appearance of a quartzitic sandstone; in other places a large part of the calcite grains have become altered to fibrous wollastonite. At the same time there has occurred a strong impregnation of graphite, so that in the neighbourhood of the cracks the rock has become almost black. These alterations decrease in intensity with the distance from the graphite veins. In the veins themselves and in places upon them there are masses of pure fibrous wollastonite, green pyroxene, and titanite, a cubic foot in size. Here also graphite occurs in hexagonal plates more than a centimeter across. If on the other hand a crack is filled completely with graphite it forms apparently a structurless mass or a fibrous aggregate. Frequently the calcite in the neighborhood of the veins has become coarsely crystalline and of a blue colour, as is the case in contact rocks from Monzoni and the Banat.

Wollastonite.

The wollastonite of the veins and their immediate neighbourhood consists either of snow-white parallel fibrous aggregates of 10—20 cm. length of fibre, and then generally almost quite pure, or an irregular coarsely columnar aggregate and is then abundantly intergrown with pyroxene and titanite. Microscopically the apparently pure mineral contains small augite lamellæ. The c axis of the latter is parallel to the fibres or b axis of the former. Graphite and pyrite frequently occur in irregular cross cracks, and they are therefore in part younger than the wollastonite.

An analysis by Bunce (Dana's Mineralogy, 1850) gave :

	I.	II.
SiO_2	53·03	0·8838
FeO	1·20	0·0167
CaO	45·74	0·8168
	99·99	

Under II. the molecular proportions are given. The composition is :

$$0{\cdot}8168 = 90{\cdot}71\%\ CaSiO_3$$
$$0{\cdot}0167 = 1{\cdot}85\%\ FeSiO_3$$

There remains an excess of 0·0670 SiO_2 which is perhaps caused by quartz inclusions.

The augite has a dark bottle-green colour and exhibits along with the cleavage cracks parallel to ∞ P, a parting parallel to oP. Parallel to these faces of parting microscopic liquid inclusions are arranged in bands.

Titanite abundant.

Titanite is also very abundant in pieces up to the size of one's head. Busz (40) describes two crystals from here which were about 1 cm. thick and 4 cm. long. The habitus is exactly that of the well known crystals from Renfrew, the observed faces being $P\bar{\infty}$ $\left\{ \bar{1}01 \right\}$ $P\breve{\infty}$ $\left\{ 011 \right\}$ $\frac{2}{3}P\breve{2}$ $\left\{ \bar{1}23 \right\}$ and $-2\,P\breve{2}$ $\left\{ 121 \right\}$ according to Naumann's orientation. I found only massive pieces of a resin brown colour.

A parting parallel to two faces is very characteristic and complete and gives with the goniometer very good reflections from surfaces making an angle of 54° 29′. This is almost identical with those found by Busz for the titanite from Renfrew (54° 30′). From these he calculates a parting parallel to $\frac{4}{5}P\breve{4}$. In consequence of this parting the mineral is very crumbly and fragile.

Zircon is decidedly more scarce than the three minerals described above. I was able to find only two small crystals in the material collected, and these were somewhat over 0·5 cm. long and about 1 mm. thick. They exhibit the forms ∞ P $\left\{ 110 \right\}$ 3 P $\left\{ 331 \right\}$ 3 P 3 $\left\{ 311 \right\}$ and P $\left\{ 111 \right\}$ The termination of the crystal is sharp, as in the accompanying figure, on account of the preponderance of 3 P and 3 P 3. The colour is light violet gray.

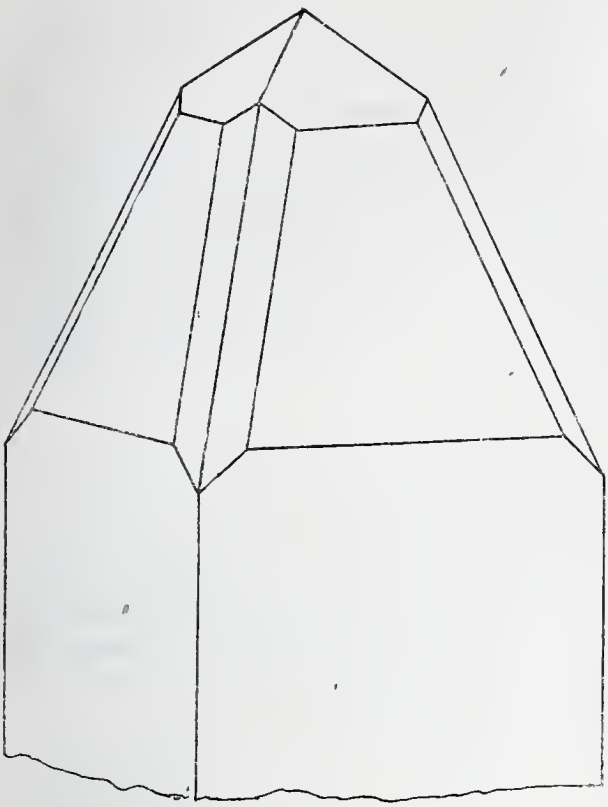


Fig. 12. Zircon from Grenville.

Hoffmann ([41]) gives vesuvianite and garnet as minerals accompanying the graphite at Grenville; during the short time of my stay I was unable to find these.

Limestone cut by eruptive rock.

In one of the openings the granular limestone is cut by a vein of eruptive rock. It is compact, of green violet gray - colour with a few lath-shaped little feldspar phenocrysts. The rock is about 0·5 m. thick and becomes finer in grain along the edges. Under the microscope it is seen to be much altered, only a few large plagioclase crystals being quite fresh. In the groundmass one recognizes very much altered plagioclase and sections of a prismatically developed mineral that is completely decomposed. On the contact with the limestone the feldspars of the groundmass exhibit fluidal arrangement and lie in a brown mass which consists for the most part of tiny double refracting grains which are probably alteration products of a glass. Probably the rock is closely related to the augite porphyrites already described from the neighbouring apatite region.

Analysis of graphite by Hoffmann.

Hoffmann ([42]) has made a series of analyses of graphite, both from various localities in the townships of Grenville and Buckingham, the results of which are given in the report here referred to. The most important results which have been derived from the investigation of the occurrences of graphite at Grenville and Graphite City, may be summed up as follows:

1. In both occurrences the graphite appears as matter filling veins and cracks, and is therefore younger than the containing rock. The strike of these veins is independent of that of the crystalline schists cut

by them. In many of the veins graphite is the only vein mineral, as at Graphite City. In other cases pyroxene, green apatite, scapolite, titanite, and wollastonite are also present; these with the exception of wollastonite, are the most abundant minerals of the apatite veins.

Country rock impregnated with graphite.

2. From these veins the country rock has been impregnated with graphite, particularly in the case of the crystalline limestones which, no doubt, on account of their somewhat loose structure, have shown themselves most susceptible to this influence. In the case of the gneisses this impregnation has been confined essentially to the layers richest in mica, along which also the rock breaks most easily. Particularly at the Main pit in Graphite City these impregnations have gone so far that the granular limestone is mined for graphite.

3. Along the contacts of the graphite veins, the neighbouring rocks have suffered alteration into scapolite and pyroxene, as is characteristic in the case of the apatite veins. There have thus been formed masses which cannot be distinguished from many of the 'pyroxenites' of the apatite regions (Graphite city). At Grenville, the granular limestone has been converted into a mixture of pyroxene, wollastonite, and titanite. In places they are so strongly impregnated with silica that a rock similar to quartzite has been formed.

In both cases minerals have been formed which are essentially the same as one is accustomed to observe in limestones which have undergone contact metamorphism. This contact metamorphism of the limestone can be explained only by the assumption that the limestone has been penetrated by gases and vapours from the neighbouring eruptive magma, and upon further cooling perhaps also by solutions, and that in this way the materials foreign to the limestone, especially the silica, have been introduced.

Further discoveries of graphite at Grenville probable.

The assumption of a similar process in the formation of the graphite veins is most probable. At Graphite City plutonic rocks have been recognized at several places close to the graphite veins. At Grenville this was not possible (the augite porphyrite there occurring in veins, certainly has nothing to do with such a process); however it must not be forgotten that nothing is known geologically of the region even immediately around the graphite works. Perhaps the immense mass of syenite whose boundary is only about a mile to the east should be considered in this connection. I am thoroughly convinced that the graphite veins at Grenville are not of isolated occurrence, as is the case at Graphite City, but that the wooded character of the country has prevented further discoveries of graphite in the neighbourhood.

In one respect these two occurrences differ, for in that at Graphite City the plutonic rock itself is cut by graphite veins. One must, therefore, here suppose a process conditioned, as in the case of the tin ore and apatite veins, by fumarole action after the cooling or solidifying of the eruptive rock. The occurrence of apatite and graphite veins in such close proximity in the province of Quebec and exhibiting so much in common mineralogically and geologically shows that they have had a similar or analogous origin. One needs only to be reminded of the occurrence of graphite in apatite veins, and conversely of apatite in graphite veins. The latter is reported from Ceylon in all geological descriptions.

Origin of graphite in granular limestone.

Graphite is widely distributed in the granular limestone of Canada, but is as far as my knowledge goes, however, present only in small quantities. That this graphite has been derived from carbon originally present in the limestone and probably of organic origin, seems to me to be without doubt. By the same process of metamorphism by which the limestone was converted into marble, this graphite has also been formed. The graphite of the veins which have been described has, however, certainly nothing to do genetically with this other graphite sparsely and evenly distributed. A short time ago Weinschenk ([38]) came to the same conclusion in regard to the graphite veins of Ceylon.

According to this theory the source of the carbon forming the graphite must be sought deep down in the earth. As to the chemical form in which it was present as a constituent of volcanic fumaroles, we know at present very little. Weinschenk supposes that it was in the form of cyanogen compounds. It may be pointed out that quite recently Cohen has found in the nickel-iron of Ovifak and Niakomak, which is now supposed by all to be of terrestrial origin, the same iron carbide which under the name of cohenite has been known for a long time as a constituent of meteoric iron. Further the inclusions of liquid carbon dioxide especially in the quartz of eruptive rocks, can only be supposed to have originate from an original content of carbon in the fused masses of the earth's crust.

C. H. Gordon's paper on syenite gneiss.

'It was only while correcting this report that I became aware of Mr. C. H. Gordon's paper on the syenite gneiss (leopardrock) from the apatite region of Ottawa county, Canada.* The investigations of the author are essentially confined to the occurences at the High Rock mine. The results of his work which have for us a particular interest for us are as follows :—

* Bull. Geol, Soc. Am., Vol. VII., 1896.

Intrusive nature of syenite gneiss certain.

(*a.*) The syenite gneiss occurs in dyke form in pyroxenite, gneiss and quartzite and cuts across the latter in part at right angles to the strike. There can therefore be no doubt as to its intrusive nature, and its younger age in relation to the later rocks.

(*b.*) The syenite gneiss occurs in three structurally different modifications, which are united to one another, sometimes in one and the same rock mass, by transition forms, as coarse-grained syenite gneiss, as ellipsoidal syenite gneiss, and as streaked syenite gneiss.

1. The coarse-grained modification is made up of irregular shaped angular blocks of coarse-grained rock (sometimes as much as two inches in diameter) which are separated from one another by a network of fine-grained mineral aggregates.

2. In the ellipsoidal syenite gneiss these coarse-grained blocks are no longer irregular but are rounded ellipsoidal, or egg-shaped.

3. Through the latter becoming flatter and ovoid, transition forms to the streaked syenite gneiss (Modification 3) are developed. In this last, these are so flat that a lenticular structure with an alteration of coarse and fine-grained bands results although the difference in the grain is not so marked as in Modifications 1 and 2.

Accessory minerals.

(*c.*) Mineralogically all these modifications are of like composition. Feldspar (in greater part microcline), green pyroxene, and quartz are the essential constituents. Accessory to these are titanite, apatite (in places in masses of over one foot in diameter), pyrite, mica, hornblende (in part alteration product from pyroxene) calcite, and sparingly also rutile and tourmaline. The coarse-grained blocks consist essentially of feldspar, with subordinate quartz and isolated well-formed pyroxene crystals. The fine-grained network lying between is coloured more or less intensely green and in it the augite, titanite, pyrite, and the other accessory minerals are more strongly developed. The pyroxene prisms and needles are here in part regularly arranged ; they lie with their long axis normal to their contact with the enclosed coarse masses

(*d.*) The whole rock shows pressure effects which are particularly intense in Modification 3, the streaked syenite gneiss. According to the whole description, the lenticular structure has been produced through the crushing together with perhaps also the rolling out of the coarse constituents of Modifications 1 and 2. The greatest extreme of pressure is in the network whose structure is to be directly designated as mortar (mörtel) structure.

(*e.*) With respect to the origin of these peculiar structural relationships, the author discusses different possibilities and sets forth the following hypothesis as the most probable :—

Structure of leopard rock.

(1.) The structure characterizing the leopard rock is due to orographic agencies and represents an intermediate stage in the development of a streaked augite-syenite gneiss out of an augite-syenite which was distinguished by a coarsely crystallized structure and by a somewhat irregular aggregation of pyroxene. The character of the original magma may have been modified somewhat by the absorption of included fragments of pyroxenite.

(2.) The distribution of the pyroxene has been effected presumably by the solution of portions of the original constituents and their crystallization along lines marking the location of cracks.

(3.) With continued pressure these lumps (the coarse-grained blocks) have been more and more drawn out, the process being accompanied by recrystallization until the rock assumed the streaked gneissoid form."

The rocks which I had an opportunity of studying belong to Gordon's Mod. 2, the coarse-grained blocks being in part completely spherical. The boundary between these and the fine-grained material is seen to be conditioned through original more or less spherical jointing. If such rocks are strongly squeezed these spherical masses become more and more flattened and consequently a lenticular structure is induced. At the same time effects of pressure, such as the crushing of the constituents, the production of a mortar structure, &c., are more pronounced along joint planes in which the cementing is weaker and more open than in compact coarse blocks, therefore the pressure effects are more pronounced in the network. So far one can completely agree with points 1 and 3 of the author. On the other hand I am convinced that the unequal distribution of the minerals, particularly the strong enrichment in pyroxene, apatite and pyrite, as also the occurrence of rutile and tourmaline, in the fine-grained net work, is not as the author believes a sort of lateral secretion in the syenite gneiss itself, but originates from an impregnation along these joint fractures of materials from without, which work their way into the coarse-grained blocks. This impregnation phenomenon took place contemporaneously with the formation of the apatite veins.

Reason of unequal distribution of minerals.

The whole process was developed in the following way :—First of all came the intrusion of stock and dyke formed masses of gabbro and a part of the pyroxenite, in the gneiss and quartzite. Probably soon

after came the formation of the syenite gneiss dykes, in which were formed both spherical and more or less irregular joint-planes. Then followed the development of the apatite veins and a part of the pyroxenite (newly formed from the apatite veins themselves), and at the same time impregnation of the neighbouring rock through solutions and pneumatolitic action. Lastly came the pressure effects which gave to the syenite the structure of a lenticular (flaser) gneiss.

Literature Consulted.

1. Adams. Report on the geology of a portion of the Laurentian area lying to the north of the Island of Montreal. Annual Report Geol. Surv. Can. Vol. VIII., (N.S.) 1896.
2. Osann. Versuch einen chemischen Classification der Eruptivgesteine. Tsch. M. M. XIX., 1900.
3. Sterry Hunt. On the examination of various minerals, mineral localities and mineral waters. Report of Progress, Geol. Surv. Can., 1847-48.
4. Sterry Hunt. On the geology and mineralogy of the Laurentian limestones, geology of petroleum and salts, &c. Report of Progress, Geol. Surv. Can., 1863-66.
5. Sterry Hunt. Geology of Canada, 1866.
6. Sterry Hunt. The apatite deposits of Canada. Transact. Amer. Inst. of Min. Engin., 1884.
7. Sterry Hunt. Note on the apatite region of Canada. Transact. Amer. Inst. of Min. Engin., 1885.
8. J. W. Dawson. Notes on the phosphate of the Laurentian and Cambrian rocks. Quart. Journ. Geol. Soc., 32, 1876.
9. B. J. Harrington. Report on the minerals of some of the apatite-bearing veins of Ottawa Co. Report of Progress, Geol. Surv. Can., 1877-78.
10. J. F. Torrance. Report on apatite deposits, Ottawa Co., Quebec. Report of Progress, Geol. Surv. Can., 1882-84.
11. W. B. Dawkins. On some deposits of apatite near Ottawa, Canada. Trans. Manchester Geol. Soc., 18, 1885.
12. G. H. Kinahan. On a possible genesis of the Canadian apatite. Trans. Manchester Geol. Soc., 18, 1885.
13. G. M. Dawson. On the occurrence of phosphate in nature. Trans. Ottawa Field Club, 1884.

14. J. F. Falding. On notes on Canadian fluor apatite, &c. Engin. and Min. Journ., 1886.

15. R. Bell. On the mode of occurrence of apatite in Canada. Engin. and Min. Journ., 1886.

16. E. Coste. Report on the mining and mineral statistics of Canada. Annual Report Geol. Surv., Can., Vol. III., (N.S.) 1887-88.

17. R. A. F. Penrose. Nature and origin of deposits of phosphate of lime. Bull. U. S. Geol. Surv., No. 46, 1888.

18. A. R. C. Selwyn. Annual Report Geol. Surv. Can. Vol. IV, (N.S.) 1888-89.

19. W. B. M. Davidson. Notes on the geological origin of phosphate of lime in the United States and Canada. Trans. Am. Inst. Min. Eng., 1892.

20. R. W. Ells. The phosphate deposits of the Ottawa District. Canad. Min. Review, XII., 1893.

21. F. D. Adams and A. C. Lawson. On some Canadian rocks containing scapolite, with a few notes on some rocks associated with the apatite deposits. Can. Record of Sci., 1888.

22. A. Lacroix. Contributions à l'étude des gneiss à pyroxène et des roches a wernérite. Bull. Soc. Min., XII., 1889.

23. F. W. Clarke and E. A. Schneider. Experimentaluntersuchungen über die Constitution der natürlichen Silikate. Zeitschr. f. Krystallogr., XVIII., 1891.

24. W. C. Brögger und H. H. Reusch. Vorkommen des Apatits in Norwegen. Zeitschr. d. deutsch. geol. Geo., 27, 1875.

25. G. Rose. Über die regelmässigen Verwachsungen der verschiedenen Glimmerarten unter einander sowie mit Penin und Eisenglanz. Ber Berl. Akad., 1362 und 1869.

26. G. Tschermak. Die Glimmergruppe. Zeitschr. f. Krystall, 2, 1878.

27. F. Sandberger. Über Rutil in Phlogopit, Asterismus des letzteren, etc. N. Jahrb. Min., 1882, II.

28. A. Lacroix. Sur les inclusions de la phlogopite de Templeton (Canada). Bull. Soc. Mineral., 8, 1885.

29. H. Rosenbusch. Mikroscopische Physiographie der petrographistch wichtigen Mineralien, 1892.

30. C. Hoffmann. Chemical contributions to the geology of Canada. Report of Progress, Geol. Surv. Can., 1877-78.

31. A. Carnot. Über die in der Zusammensetzung des Apatits beo bachteten Verschiedenheiten. Bull. Soc. Min., 19, 1896.

32. J. A. Voelcker. Die chemische Zusammensetzung des Apatits nach eigenen volständigen Analysen. Ber chem. Gesellsch., 16, 1883.

33. J. H. L. Vogt. Beiträge zur genetischen Classification der durch magmatische Differentiationsprozesse und der durch Pneumatolyse entstandenen Erzvorkommen. Zeit. prakt. Geol., 1895.

34. J. W. Dawson. Specimens of Eozoon Canadense and their geological and other relations. McGill University, 1888.

35. H. J. Johnston-Lavis and J. W. Gregory. Eozoonal structure of the ejected blocks of Monte Somma. Trans. Roy. Dublin Soc., 5, 1894.

36. F. Sandberger. Beitrag zur Kenntniss des Graphits von Ceylon und seiner Begleiter. Neues Jahrb. Min., 1887, II.

37. Fr. Grünling. Über die Mineralvorkommen von Ceylon. Zeit. für Krystall, 33, 1900.

38. E. Weinschenk. Die Graphitlagerstätten der insel Ceylon. Abh. Bayr. Akad. Wiss. 21, 1900.

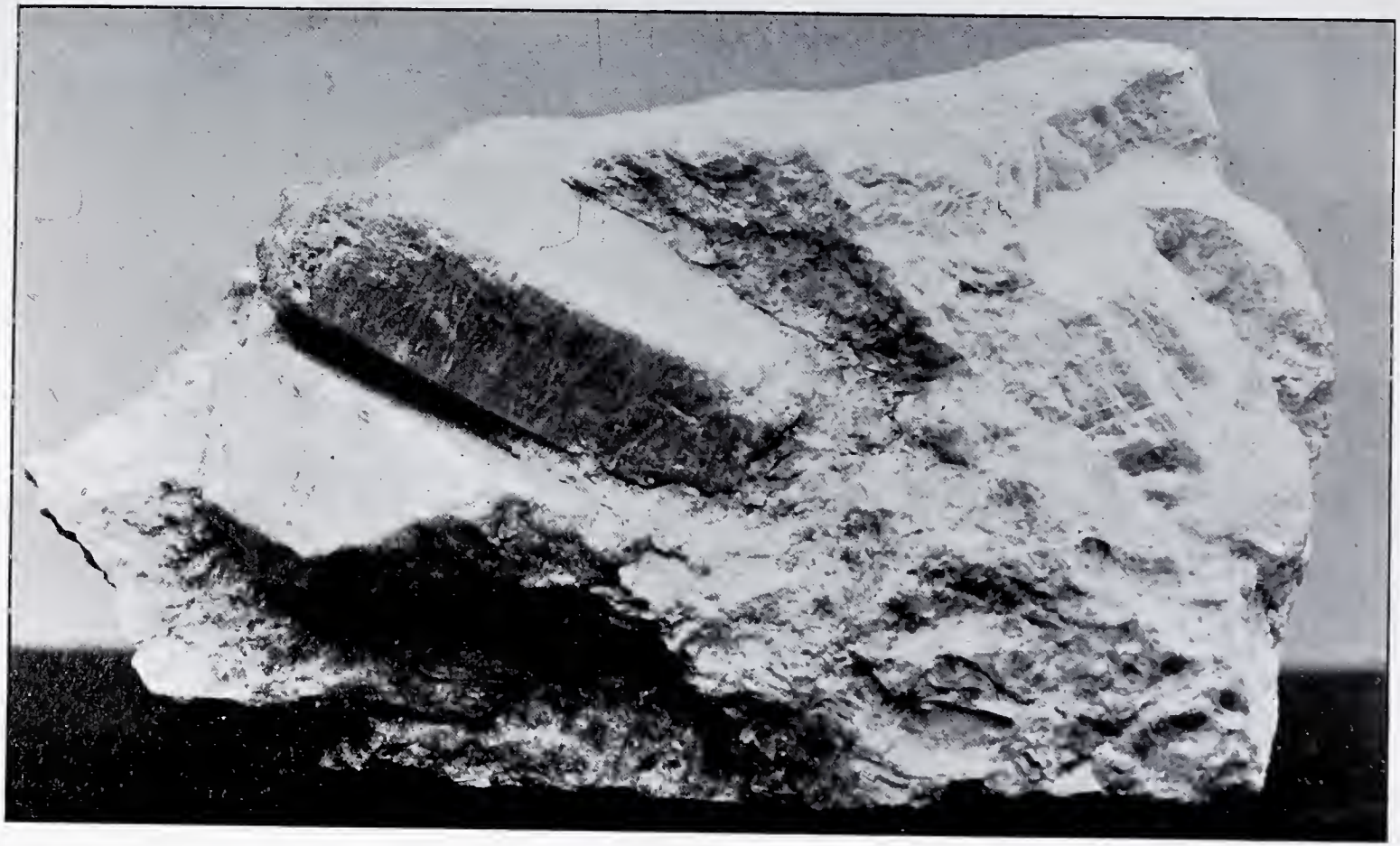
39. B. J. Harrington. Notes on a few Canadian minerals and rocks. Report. of Progress, Geol. Surv. Can., 1874-75.

40. K. Busz. Beitrag zur Kenntniss des Titanits. Neues Jahrb. Min., V., B.B.

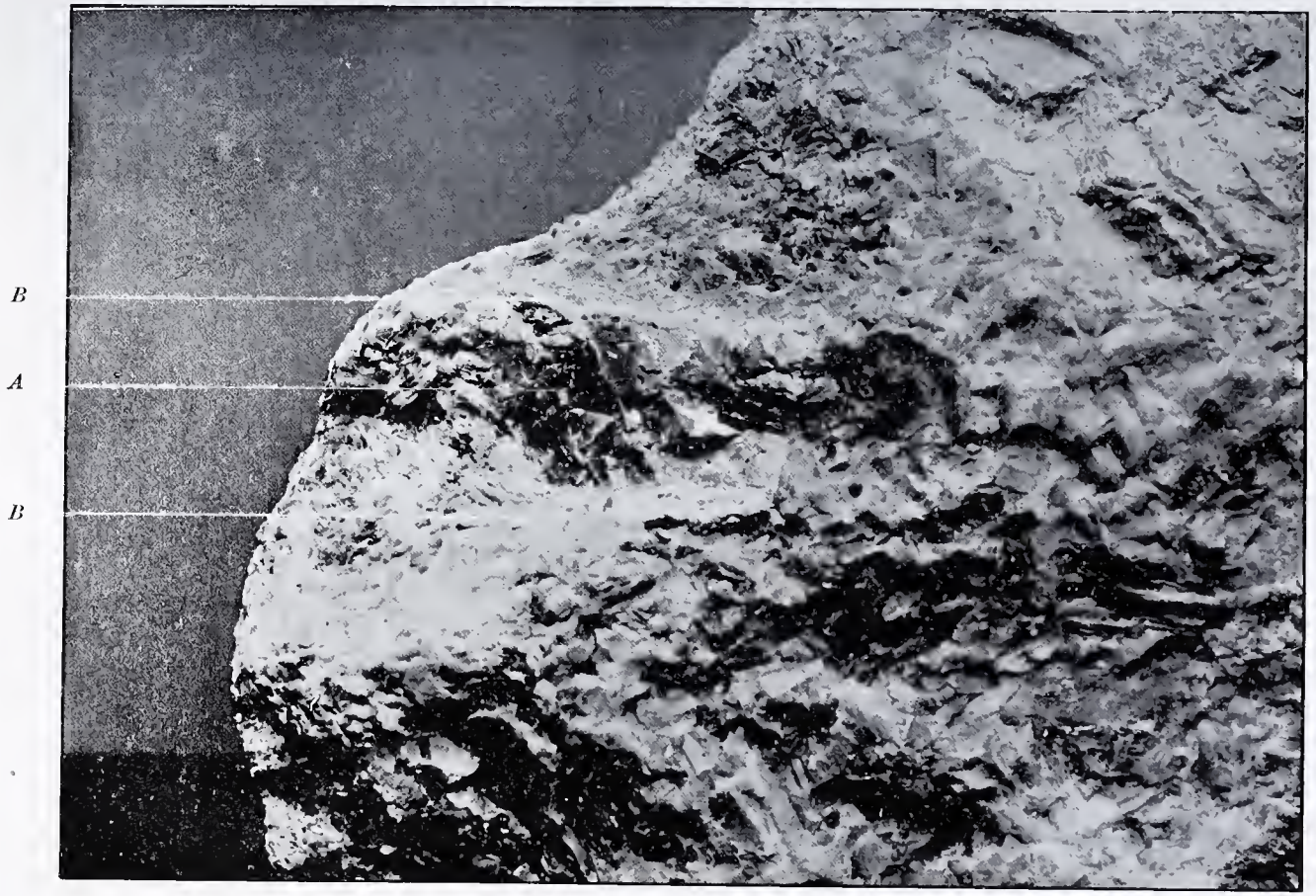
41. C. Hoffmann. Annotated list of the minerals occurring in Canada. Annual. Report Geol. Surv., Can., Vol. IV (N.S), 1888-89.

42. C. Hoffmann. Chemical contributions to the geology of Canada. (On Canadian graphite.) Report of Progress, Geol. Surv. Can., 1876-77.

43. E. Cohen. Über des Vorkommen von Eisencarbid (Cohenit) im terrestrischen Nickeleisen von Niakomak bei Sakobshavn in Nord Grönland. Meddelelser om Grönland, XV.



Apatite crystals in coarse spathic Calcite.—Vavasour mine.

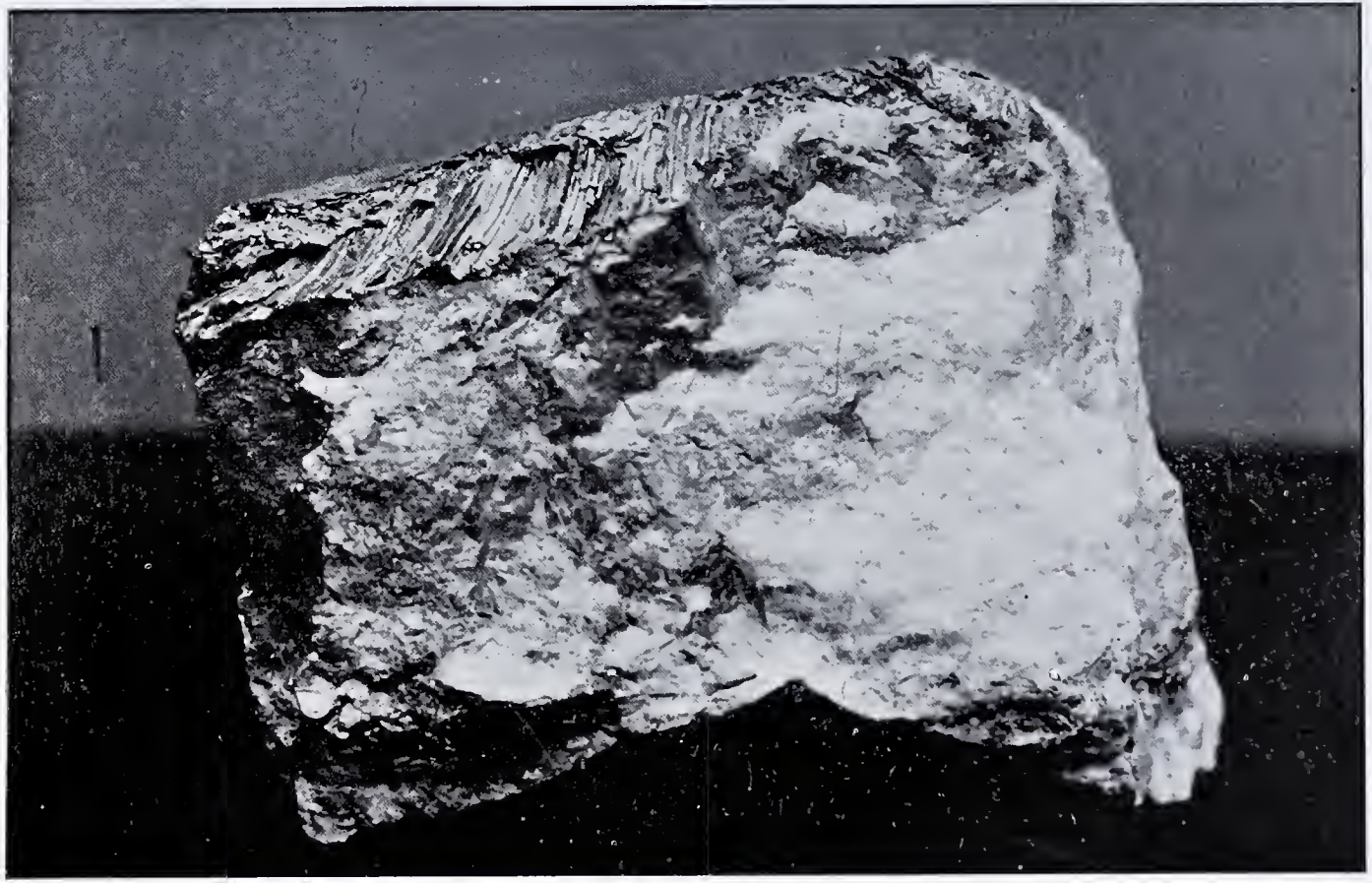


Augite-crystal encrusted with apatite in coarsely crystalline Calcite.—*A*, Augite; *B*, Apatite border.
(See page 26).

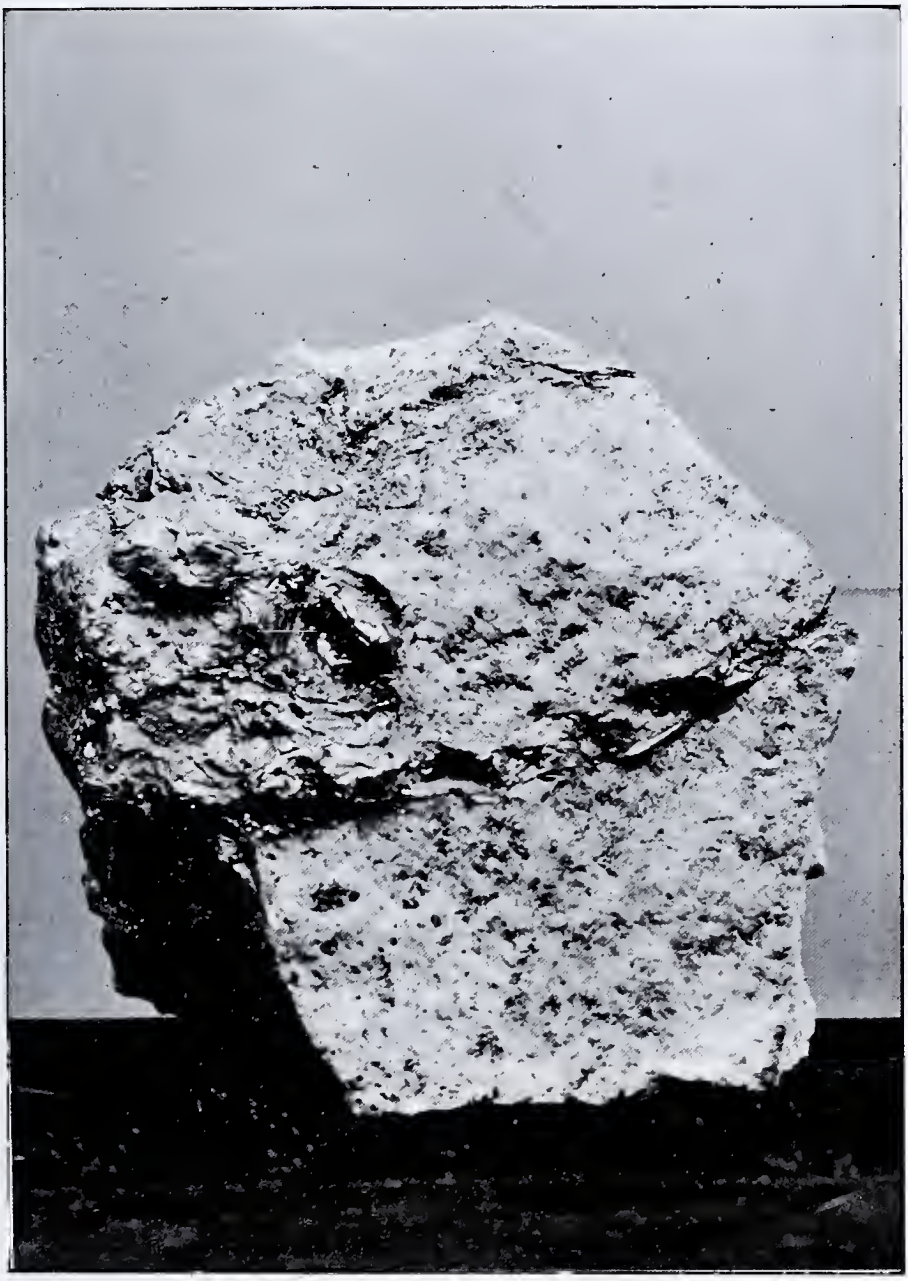
Pyroxene Apatite "Pyroxenite."—The lighter portion consists of Green Apatite, the darker of rudely prismatic Augite.—Union mine. (See page 48).

'Pyroxenite.'—'Eyes' of Pyroxene lie in an aggregate of Pyroxene and Phlogopite.—Vavasour mine. (See page 48).

Leopard Granite.—The large dark portion in the lower right hand quarter is very rich in pyrite. (See pages 26 & 56).



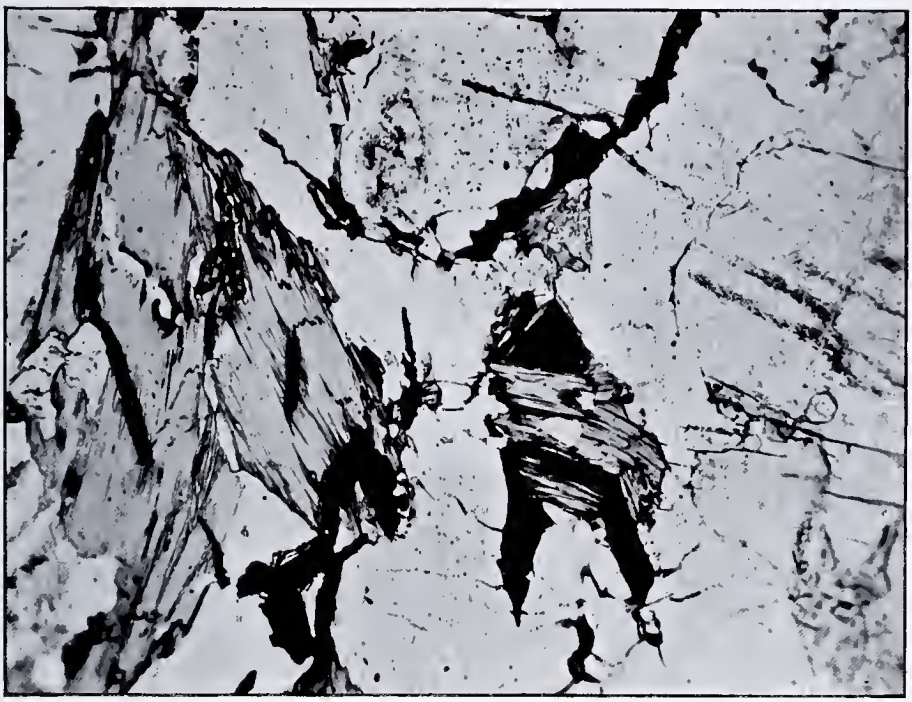
Stringer of Columnar Graphite in Pegmatite.—Nelly's Pit, Graphite City.



Graphite Stringers pinching out in Granular Gneiss from a Graphite vein.—Nelly's Pit, Graphite City.

Fig. I.—Scapolite gabbro. Vavasour mine. Scapolite and Augite in part uralitized. (See page 50).

Fig. II.—Lime Silicate-hornfels, consisting of Pyroxene, some Amphibole and Titanite.



Figs. I. and II.—Graphite Gneiss from Main Pit., Graphite City. (See page 72).

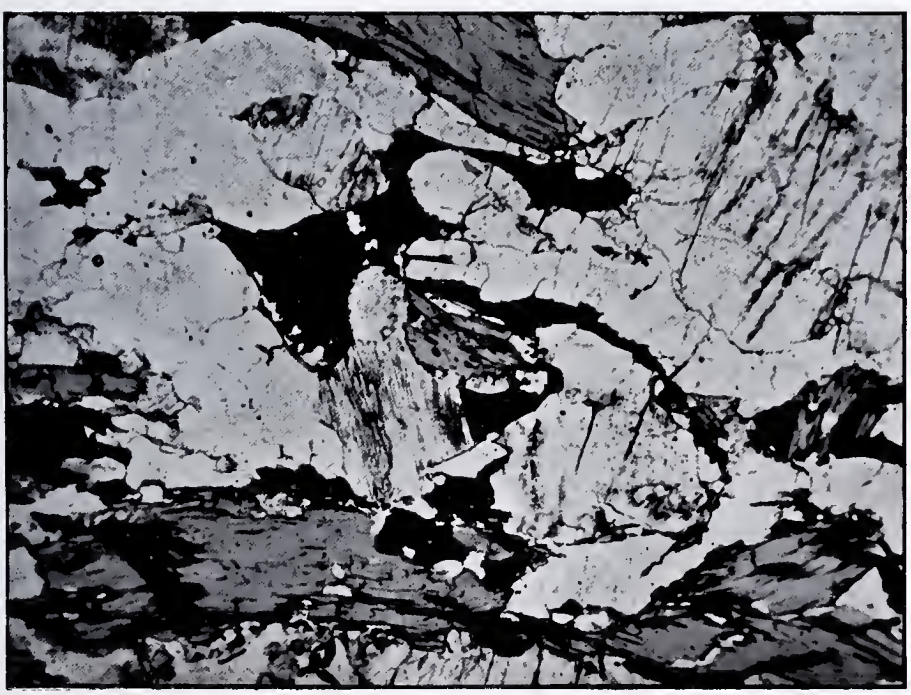


Fig. II.

Fig. I.—Pyroxene from Scapolite gabbro, Vavasour mine. (See page 21).

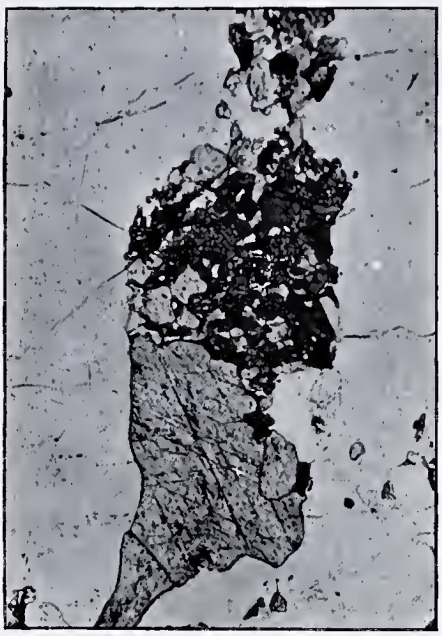


Fig. II.—Quartzite from the Squaw Hill mine with vein consisting of Pyroxene, Scapolite, Titanite, etc. (See page 26).

Fig. III.—Phlogopite with inclusions, North Star mine. (See page 32).

Fig. IV.—Scapolite with characteristic inclusions.

Fig. I.

Fig. II.

Plagioclase with granophyric corrosion vein, Graphite City. (See page 70).

Fig. III.—Scapolite Pyroxene, contact rock, Côte St. Pierre. (See page 65).

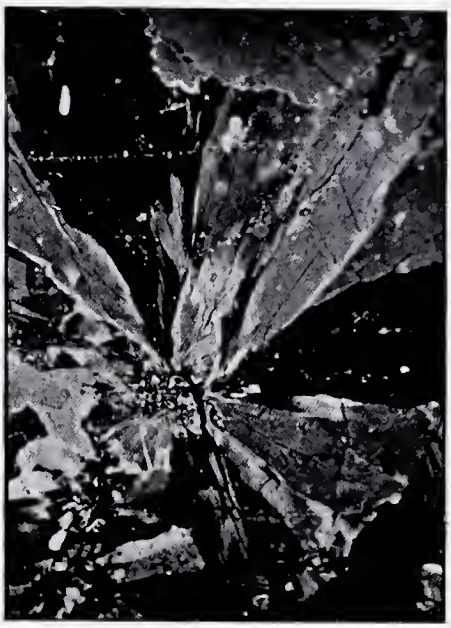


Fig. IV.—Scapolite spherulite, contact rock of Côte St. Pierre. (See page 65).

GEOLOGICAL SURVEY OF CANADA
ROBERT BELL, M.D., D.Sc., LL.D., F.R.S., DIRECTOR

REPORT

OF THE

SECTION OF CHEMISTRY AND MINERALOGY

BY

G. CHRISTIAN HOFFMANN, LL.D., F.I.C., F.R.S.C.,
Chemist and Mineralogist to the Survey.

ASSISTANTS

F. G. WAIT, M.A., F.C.S.
R. A. A. JOHNSTON.

OTTAWA
PRINTED BY S. E. DAWSON, PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1901

724.

To

ROBERT BELL, M.D., D.Sc., LL.D., F.R.S.,

Director of the Geological Survey of Canada.

SIR,—In submitting to you the accompanying report for the past year, it should be mentioned that the same does not embrace all the work accomplished in this Laboratory during the period in question, indeed scarcely two-thirds, very many mineral determinations, qualitative examinations, and partial quantitative analyses, the results of which were of little or no interest save to those immediately concerned, having been altogether omitted.

I have the honour to be,

Sir,

Your obedient servant,

G. CHRISTIAN HOFFMANN.

OTTAWA, July 31, 1901.

TABLE OF CONTENTS.

PAGE

I.—Miscellaneous Minerals—

Cassiterite, var. wood-tin, from Hunker creek, a tributary of the Klondike, Yukon district, N.W.T 16
Danalite, from Walrus island, Paint Hills group, east coast of James bay, Ungava district, N.E.T..... 15
Datolite, from lot 9, range 1, of the township of Derry, Ottawa county, Q. 17
Faujasite, from lot 9, range 1, of the township of Derry, Ottawa county, Q. 18
Grossularite, from the White Horse copper-belt, west side of Lewes river, Yukon district, N.W.T 14
Hydronephelite, from Ice river, a tributary of the Beaver-foot, Rocky mountains, B.C 13
Lepidolite, from lot 25, range 7, of the township of Wakefield, Ottawa county, Q..... 11
Newberyite, from the tusk of a mammoth found in swamp-muck on Quartz creek, Yukon district, N.W.T..... 13
Schorlomite, from Ice river, a tributary of the Beaver-foot, Rocky mountains, B.C..... 12
Spodumene, from Walrus island, Paint Hills group, east coast of James bay, Ungava district, N.E.T..... 15
Struvite, from the tusk of a mammoth found in swamp-muck on Quartz creek, Yukon district, N.W.T 13
Uranophane, from lot 31, range 1, of the township of Villeneuve, Ottawa county, Q..... 16

II.—Mineralogical Notes—

Allophane, from the Rabbit-foot claim, White Horse copper-belt, Lewes river, Yukon district, N.W.T..... 18
Altaite, from the Pay Roll claim, Little Nigger creek, East Kootenay district, B.C..... 19
Amazonstone, from one of the islands of the Paint Hills group, east coast of James bay, Ungava district, N.E.T 19
Barite, from lot 27, concession 7, of the township of Huntley, Carleton county, O..... 19
Celestite, from Grand Manitoulin island, north shore of Lake Huron, O.. 19
Chrysocolla, from the Pueblo claim, White Horse copper-belt, Lewes river, Yukon district, N.W.T.. 19
Danaite, from lot 12, range 9, of the township of Calumet, Pontiac county, Q 19
Epidote, from Walrus island, Paint Hills group, east coast of James bay, Ungava district, N.E.T..... 20
Erythrite, from the Chickamon-stone claim, west side of Bull river, East Kootenay district, B.C..... 20
———, from the Rabbit-foot claim, White Horse copper-belt, Lewes river, Yukon district, N.W.T 20
Galena, from lot 18, concession 9, of the township of Bedford, Frontenac county, O..... 20

II.—Mineralogical Notes—*Con.*— PAGE.

Gmelinite, from the War Eagle mine, near the town of Rossland, West Kootenay district, B.C. 21
Graphite, from lot 1, concession 5, and lot 2, concession 6, of the township of Bedford, Frontenac county, O. 21
———, from lot 22, concession 2, of the township of South Canonto, Frontenac county, O. 21
Hematite, from Rocher Rouge, MacTavish bay, Great Bear lake, Mackenzie district, N.W.T. 21
Hydromagnesite, from cliffs on the south shore of Dease bay, Great Bear lake, Mackenzie district, N.W.T 22
Jamesonite, from the David Whitley or Red Paddy claim, Kettle river, Yale district, B.C. 22
Magnesite, from Discovery claim on Pine creek, and the Anaconda group of claims on the Indian Reserve, Atlin city, east side of Atlin lake, Cassiar district, B.C. 22
———, from about a mile north of Pike river, on the eastern side of the southern end of Atlin lake, Cassiar district, B.C. 22
Magnetite, from the Arctic Chief and Valerie claims, White Horse, copper-belt, Lewes river, Yukon district, N.W.T. 23
Marl, from the west half of lot 10, concession 1, of the township of Stafford, Renfrew county, O. 23
Micaceous hematite, from one of the more southerly of the Les Isles du Large group, Great Bear lake, Mackenzie district, N.W.T. 21
Molybdenite, from island No. 12 of the Paint Hills group, east coast of James bay, Ungava district, N.E.T. 23
———, from lot 16, concession 1, of the township of Brougham, Renfrew county, O. 23
———, from the Giant claim, Trail Creek mining area, West Kootenay district, B.C. 23
Monazite, from lot 31, range 1, of the township of Villeneuve, Ottawa county, Q. 24
Mountain leather, from near the village of Lower Five islands, township of Economy, Colchester county, N.S. 24
Sericite, from Bonanza creek, a tributary of the Klondike, Yukon district, N.W.T. 24
Siderite, from the south shore of Dease bay, Great Bear lake, Mackenzie district, N.W.T. 24
Silver, Native, from the Westend mine, Silver mountain, township of Lybster, district of Thunder Bay, O. 24
Specular iron, from Echo bay, east side of Great Bear lake, district of Mackenzie, N.W.T. 21
———, from the Pueblo claim, White Horse copper-belt, Lewes river, Yukon district, N.W.T. 21
Spessartite, from the township of Proudfoot, Parry Sound district, O. 25
Sphalerite, from lots 41 and 42, ranges 1 and 2, of the township of Bouchette, Ottawa county, Q. 25
Stibnite, from the Copper King and Anaconda claims, White Horse eop-per-belt, Lewes river, Yukon district, N.W.T. 25
Wilsonite, from the Rabbit-foot claim, White Horse copper-belt, Lewes river, Yukon district, N.W.T. 25

III.—Coals and Lignites— PAGE.

Anthracite, from a seam about ten miles west of Dugdale station on the line of the W. P. and Y. R., Yukon district, N.W.T. 30
Coal, from the so-called sixteen-foot seam on Collins gulch, Tulameen river, Yale district, B.C. 29
———, from the so-called twenty-foot seam on Collins gulch, Tulameen river, Yale district, B.C. 29
———, from a seam on the Stony Indian reserve, two miles south of Morley station on the line of the C.P.R. district of Alberta, N.W.T. . 30
Lignitic coal, from a seam on Lewes river, about six miles above Rink rapid, Yukon district, N.W.T. 28
Lignite, from the upper seam on Coal creek, an easterly branch of Rock creek—which is a tributary of the Klondike, Yukon district, N.W.T.
———, from the lower seam on Coal creek, an easterly branch of Rock creek—which is a tributary of the Klondike, Yukon district, N.W.T. . 26
———, from the upper working on Cliff creek, a tributary of the Yukon, Yukon district, N.W.T. 27
———, from the lower working on Cliff creek, a tributary of the Yukon, Yukon district, N.W.T. 27

IV.—Limestones and dolomites—

Limestone, from the Rokes and Morse quarry on Drury cove, Kennebecasis river, parish of Portland, St. John county, N.B. 31
———, from the first bed of Robillard and Son's quarry on lot 22, first concession of Ottawa Front, township of Gloucester, Carleton county, O. 32
———, from the third bed of Robillard and Son's quarry, on lot 22, first concession of Ottawa Front, etc. 32
———, from the fifth bed of Robillard and Son's quarry on lot 22, first concession of Ottawa Front, etc. 33
———, from the fourth bed of a quarry on lot 8, concession 1, of the township of Colborne, Huron county, O. 33
———, from the thirteenth bed of the quarry on lot 8, concession 1, of the township of Colborne, Huron county. O. 34
———, from the twenty-fourth bed of the quarry on lot 8, concession 1, of the township of Colborne, Huron county, O. 34
Dolomite, from lot 16, concession 6, of the township of Ross, Renfrew county, O. 35

V.—Iron Ores.—

Hematite, from the east branch of Doctors brook, and its tributaries Iron and McInnes brooks, Antigonish county, N.S. 35
———, from Rocher Rouge, MacTavish bay, Great Bear lake, Mackenzie district, N.W.T. 36
———, from one of the Les Iles du Large group, Great Slave lake, Mackenzie district, N.W.T. 36
Limonite, from the Grand River barrens, one mile south-west of Grand River falls, Richmond county, N.S. 36
Magnetite, from a deposit on the Old French road, two mile seasterly of the Mira R. C. chapel, Cape Breton county, N.S. 36

VI.—Nickel and cobalt— PAGE.

Pyrrhotite, from a small island off the west point of Kogaluk river, east coast of Hudson bay, Ungava district, N.E.T. 37
———, from the township of Matawatchan, Renfrew county, O..... 37
———, from the north-east quarter section of block 1, west side of Texada island, B.C 37
———, from near Kyuquot, west coast of Vancouver island, B.C..... 38
Pyrite, from lot 14, range 5, of the township of Masham, Ottawa county, Que..... 37

VII.—Gold and Silver Assays—

Of specimens from the—
Province of New Brunswick..... 38
— Quebec..... 39
— Ontario..... 42
— British Columbia..... 46
Ungava district, North-east Territory..... 39
North-west Territory..... 42

VIII.—Natural waters—

Water from a spring two or three hundred yards back from the Tobique river, east side and about a quarter of a mile above the mouth of the Wapskehegan, Victoria county, N.B. 48
———, from a spring on the east bank of the Tobique river, about a mile and three-quarters above the mouth of the Wapskehegan, Victoria county, N.B..... 49
———, of Salt brook, a stream flowing into the Tobique about two miles and a quarter above the mouth of the Wapskehegan, Victoria county, N.B..... 50
———, from a spring on the property of Mr. Hendricks, near Plumweseep station, on the line of the I.C.R., Kings county, N.B 56
———, from a spring at Bay of Seven islands, Saguenay county, Q..... 52
———, from a boring about two miles from the village of St. Grégoire, on concession Pointu, seigniory of Bécancour, Nicolet county, Q..... 53
———, from a well on the farm of Narcisse Tetreau, St. Paul l'Ermite, L'Assomption county, Q..... 57
———, from a spring at Ste. Rose, Laval county, Q..... 57
———, from a well on the east-half of lot 17, concession 10, of the township of Ramsay, Lanark county, O..... 58
———, from a well on lot 4, concession 12, of the township of Dereham, Oxford county, O 58
———, from a hot spring on Sharp point, between Sydney inlet and Refuge cove, west coast of Vancouver island, B.C 55
———, from a warm spring on the east shore of Atlin lake, ten miles south of Atlin city, Cassiar district, B.C..... 59
———, so-called 'soda-water' from a spring near Discovery claim, three miles up McKee creek, east side of Atlin lake, Cassiar district, B.C.. 60

IX.—Miscellaneous Examinations—

Clay, from near Louisbourg, Cape Breton county, N.S..... 60
———, found overlying a seamof lignite on Rock creek, Klondike river, Yukon district, N.W.T..... 60

IX.—Miscellaneous Examinations—*Con.*— PAGE.

Clay, found underlying a seam of lignite on Rock creek, Klondike river, Yukon district, N.W.T. 60
———, from Michel creek, East Kootenay district, B.C 61
———, found underlying a seam of coal on Granite creek, Tulameen river, Yale district, B. C. 61
Claystone, from four miles north of Clinton, Lillooet district, B.C. 61
Coal, from Dunsinane, Kings county, N.B 61
Graphite, disseminated, from Glendale, River Inhabitants, Inverness county, N.S. 62
———, disseminated, from lot 25, concession 5, of the township of Blythfield, Renfrew county, O. 62
———, from lot 22, concession 2, of the township of South Canonto, Frontenac county, O. 62
———, from lot 2, concession 6, of the township of Bedford, Frontenac county, O. 62
Hematite, from Cape Rouge, Inverness county, N.S. 62
Magnetite, from lot 14, range 8, of the township of Litchfield, Pontiac county, Q. 63
———, from lot 12, range 6, of the township of Sheen, Pontiac county, Q. 63
———, from a creek entering the Tulameen at Otter Flat, Yale district, B.C. 63
Marl, from the west-half of lot 10, concession 1, of the township of Stafford, Renfrew county, O. 63
Shale, Argillaceous, from lower part of Pierre shales, Lethbridge, district of Alberta, N.W.T. 64
———, Carbonaceous, from St. Liboire, township of Ramsay, Bagot county, Q. 64
———, Ferruginous, from Monument settlement, York county, N.B. 64
———, from Hay cove, Red islands, Richmond county, N.S. 63
Specular iron, Cupriferous, from the Pueblo claim, White Horse copper-belt, west side of Lewes river, Yukon district, N.W.T. 64

REPORT

OF THE

SECTION OF CHEMISTRY AND MINERALOGY.

MISCELLANEOUS MINERALS.

1. Lepidolite.

This species, which had previously been met with at but one locality in Canada, namely, that referred to by the writer in a note in the Annual Report of the Geological Survey of Canada for 1892-93, p. 29R has since been found to be a constituent of a coarse granite vein, of very considerable width, on the twenty-fifth lot of the seventh range of the township of Wakefield, Ottawa county, in the province of Quebec. The minerals composing this vein consist of white and light smoky-brown to brownish-black quartz, pinkish and light to dark verdigris-green microcline, a grayish albite having a fine bluish opalescence, and the mica in question, together with some aggregations of light purplish crystals of fluorite, and fine crystals of black and green tourmaline. The mica occurs in broad foliations having a rough, distorted hexagonal contour, and which in some instances have been found to measure fourteen by twenty-eight inches or more across. It has a pearly lustre. In thin laminæ it is transparent and colourless; in combinations of several laminæ it exhibits, on a white surface, a fine, light purplish colour; and in layers of about half an inch in thickness it has, by reflected light, a rich purplish-brown colour. Before the blowpipe it fuses easily and with much intumescence to a light yellowish-brown glass, simultaneously colouring the flame intense carmine-red. Its specific gravity, employing the air-pump, at 15·5°C.,

was found by Mr. R. A. A Johnston to be 2·858, and its analysis afforded him the following results :—

Silica	47·89
Alumina	21·16
Ferric oxide	2·52
Manganous oxide	4·19
Potassa	10·73
Lithia	5·44
Soda	1·34
Magnesia	0·36
Water (direct estimation)	1·90
Fluorine	7·41
	102·94
Less oxygen, equivalent to fluorine	3·12
	99·82

2. Schorlomite.

A mineral which, as the result of an examination by Mr. F. G. Wait, proves to be this species, has been met with, in masses of considerable size, as an accessory constituent of the nephelene-syenite rocks of Ice river, a tributary of the Beaver-foot, which flows into the Kicking Horse river, in the Rocky mountains, province of British Columbia.

It is massive, without cleavage; the colour is velvet black, here and there tarnished blue, and occasionally with pavonine tints; that of the streak, hair brown; the lustre is vitreous; it is brittle; the fracture is irregular, occasionally subconchoidal; it is opaque; fuses quietly at 3 to a black enamel; has a hardness of 6·5, and a specific gravity, at 15·5°C., of 3·802. Its analysis afforded him :—

Silica	25·77
Titanic oxide	19·95
Alumina	3·21
Ferric oxide	9·69
Ferrous oxide	8·01
Manganous oxide	0·76
Lime	31·76
Magnesia	1·22
	100·37

These figures do not afford a rational formula. If, however, it be assumed that the iron represented as being present in the ferrous condition, does not exist in the mineral as such (as would appear to be justified by the fact that a very carefully conducted qualitative exam-

ination failed to afford more than the faintest reaction for ferrous iron), but that it resulted from an interaction between titanium and iron sesquioxides during the process of solution of the mineral, (the titanous oxide being converted into titanic oxide at the expense of a portion of the oxygen of the ferric oxide, with simultaneous formation of ferrous oxide), and the above analysis be recalculated in accordance with this view, we obtain for the composition of the mineral :—

Silica	25·77
Titanic oxide	10·83
Alumina	3·21
Ferric oxide	18·59
Titanous oxide	8·23
Manganous oxide	0·76
Lime	31·76
Magnesia	1·22
	100·37

which figures afford a formula closely analogous to that required for garnet, and according with that now generally accepted for schorlomite.

3. Hydronephelite.

In the course of a lithological examination of a series of specimens of the nepheline-syenite of Ice river—above referred to under schorlomite, Dr. A. E. Barlow separated, by Thoulet's solution, from the rock, in which they are quite abundant, some minute, white to pinkish spherules, having a radiated structure, and a specific gravity, as determined by him, of 2·243-2·275. An analysis of these spherules, by Mr. Johnston, showed them to have the following composition :—

Silica	42·80
Alumina	28·50
Ferric oxide	0·34
Lime	1·90
Soda	14·33
Potassa	0·30
Water	10·81
	98·98

4. Newberyite and Struvite.

A material corresponding in composition to a mixture of these two minerals, has recently been obtained from partings resulting from the

drying up of the soft material of the concentric rings of interglobular spaces in the ivory of the tusk of a mammoth which was found at a depth of some fifteen feet in a surface bed of dark frozen swamp-muck, overlying stream-gravels, on Quartz creek, a tributary of Indian river, which flows into the Yukon some twenty miles south of Dawson city, Yukon district, in the North-west Territory.

The material occurred in the spaces in question in the form of readily removable plates of from one to two millimetres in thickness, which were at first colourless and transparent, but on exposure to the air, became white and lost their transparency. In the closed tube it gives off water and ammonia and becomes opaque. When heated before the blowpipe, it imparts a green colour to the inner flame and fuses at about 3 to a white enamel, which, when moistened with a solution of cobalt nitrate and reheated, assumes a beautiful pink colour. It is slightly soluble in water, and readily and completely so in cold, dilute hydrochloric, nitric or sulphuric acid.

Its analysis afforded Mr. Johnston the following results:

Phosphorus pentoxide	38·53
Magnesia	21·93
Ammonia	1·94
Water, by difference	37·18
Carbon dioxide	0·42
	100·00

These figures afford a ratio closely agreeing with the following formula:

$$7\,(HMgPO_4 + 3H_2O) + 2(NH_4MgPO_4 + 6H_2O) + \text{a trace of } MgCO_3$$

Newberyite. Struvite. Magnesite.

5. Grossularite.

A faint yellowish light-gray, wood-brown, occasionally brownish-gray, compact massive, and, more rarely, yellowish-brown and reddish-brown, imperfectly crystalline, grossularite, is met with in considerable abundance in the White Horse copper-belt, on the west side of Lewes river, opposite White Horse and Miles canyon, Yukon district, in the North-west Territory, where it is a very common, indeed the chief, constituent of the gangue of the copper-ore—bornite. Mr. Johnston

found it to have a specific gravity, at 15·5° C., of 3·603, and, conformably with the results of his analyses, the undermentioned composition :

Silica	38·94
Alumina	15·11
Ferric oxide	6·30
Manganous oxide	0·78
Lime	36·93
Magnesia	1·62
Loss on ignition	0·35
	100·03

6. Danalite.

A few crystals of what has been identified by Mr. Johnston as the somewhat rare mineral danalite, have been observed by him scattered through the felspar of a vein-stone composed of orthoclase, spodumene and quartz, which was found by Mr. A. P. Low, cutting syenite on Walrus island, Paint Hills group, east coast of James bay, Ungava district, North-east Territory.

The crystals are mostly minute, seldom exceeding a millimetre in diameter ; one, however, was found, and that the only one of any appreciable dimensions in some twenty pounds of the rock, which measures fifteen millimetres across. It is a contact twin of two tetrahedrons, and on some of the faces is triangularly marked by successions of crystal growth. On some of the more minute crystals the rhombic dodecahedral plane—which is striated in the direction of the longer diagonal, is largely developed, sometimes obscuring the tetrahedral plane.

It has a faint yellowish orange-gray (faint yellowish-brown) colour ; is translucent ; has a resinous lustre ; affords a yellowish-white streak ; is brittle, and breaks with a subconchoidal fracture. The hardness is 6, and the specific gravity, at 15·5° C., 3·25. Before the blowpipe, it fuses at about 5 to a black enamel. With soda on charcoal, it gives a slight coating of zinc oxide. It is perfectly decomposed by hydrochloric acid, with evolution of hydrogen sulphide and separation of gelatinous silica.

7. Spodumene.

This species has been identified by Mr. Johnston as being a prominent constituent of a micaless orthoclastic granitic vein-stone, found by Mr. A. P. Low cutting syenite on Walrus island, Paint Hills group, east coast of James bay, Ungava district, North-east Territory.

The mineral occurs in more or less well-individualized grayish-green subtranslucent prisms, some of which measure more than ten centimetres in length and from eight to ten millimetres in diameter. It has one well-developed prismatic cleavage, the lustre of which is pearly, while that of the cross fracture, which is uneven, is vitreous. The hardness is nearly 7. Before the blowpipe, it swells up and fuses at about 4 to a white glass, imparting at the same time a bright purplish-red colour to the flame. The finely powdered mineral is not acted upon by hydrochloric acid.

8. Uranophane.

A mineral which, on examination by Mr. Johnston, proved to be as anticipated by the writer, uranophane, has been found associated with gummite, uraninite, black tourmaline, white, light gray, pale olive-green and bluish-green apatite, spessartite, monazite, and green and purple fluorite, in a coarse pegmatite vein—composed of white and light to dark smoky-brown quartz, microcline, albite and muscovite, which traverses a gray garnetiferous gneiss on the thirty-first (and adjoining lots) of the first range of the township of Villeneuve, Ottawa county, in the province of Quebec.

The mineral which, in this instance, is evidently an alteration-product of gummite, occurs in small, bright, lemon-yellow fibrous masses, sometimes in immediate contact with the gummite found coating the uraninite or, per se, embedded in the albite immediately surrounding the tourmaline and often invading the latter. In the closed tube it blackens and gives off water. Before the blowpipe, it affords, with salt of phosphorus, in the oxidizing flame, a yellowish-green bead, which, on reheating in the reducing flame, assumes a fine green colour. Warm hydrochloric acid decomposes it, with separation of flocculent silica.

9. Cassiterite, var. Wood-tin.

The variety of tin-stone called wood-tin, has been met with in the form of small irregularly shaped nodules, scattered through the auriferous gravel of nearly all the tributaries—but, so far, most frequently in that of Bonanza and Hunker creeks—of the Klondike river, Yukon district, in the North-west Territory.

A specimen of the mineral from a claim on Hunker creek, which was sent to the writer for identification, consisted of a small water-

worn nodule of about a centimetre in its greatest diameter, exteriorly brownish-black, almost black, with a greasy lustre, but interiorly of a light to dark reddish-brown colour, dull in lustre, and, although very compact, exhibiting a divergingly fibrous structure in one direction and a concentrically lamellar one in the other. According to the finder of this specimen—Mr. W. T. Foster, some very much larger nodules of the mineral than the one just described, have since been found in the gravel of Bonanza creek.

10. Datolite.

A specimen of a mineral was recently submitted to the writer for identification, which had been met with by Mr. Bush Winning in some abundance, in the workings of the Daisy mica mine, on the ninth lot of the first range of the township of Derry, Ottawa county, in the province of Quebec, which on being examined by Mr. R. A. A. Johnston, proved to be datolite. Mr. R. L. Broadbent has since visited the mine in question and collected a fine series of specimens which not only fully illustrate its mode of occurrence, but likewise its various mineral associations. On transferring these specimens to me, Mr. Broadbent drew my attention to some small white, occasionally colourless, octahedral crystals which he had observed on some of them. These crystals were also examined by Mr. Johnston, and identified by him as the somewhat rare mineral faujasite, a species not previously recognized as occurring in Canada.

The datolite occurs in the form of hard, compact, irregularly shaped, at times more or less nodular, masses some of which are of quite small dimensions while others are of considerable size—one having been found which measures six inches across, and weighs thirteen pounds. It has also occasionally been met with in the form of moist plastic masses, which on exposure to the air become crumbly and ultimately fall to pieces, forming a loose earth. The masses in question occur imbedded in a matrix composed of an association of a light to somewhat dark greenish-gray, more or less weathered, pyroxene, brown phlogopite, light grayish to white cleavable calcite, grayish-white translucent to colourless transparent quartz, and bluish-green, more rarely faint purplish, yellowish and colourless fluorite, with some intermingled pyrite and pyrrhotite, and small quantities of barite, chabazite and faujasite.

The mineral is greenish-white to all but white in colour; is almost opaque; has a dull lustre; is brittle; breaks with an uneven to subconchoidal fracture—the fractured surface resembling that of fine stone-

ware (Wedgwood-ware). It has a hardness of 5 and a specific gravity, at 15·5° C., of 2·985. Before the blowpipe, it fuses with slight intumescence, at about 2 to a clear glass, simultaneously colouring the flame yellowish-green. In fine powder it is easily and completely decomposed by hydrochloric acid, with separation of gelatinous silica.

The mean of two very closely concordant analyses, conducted by Mr. Johnston, showed it to have the following composition :

Silica	36·94
Boron trioxide	22·37
Lime	34·90
Alumina	0·12
Ferric oxide	0·02
Magnesia	0·05
Water (direct estimation)	5·68
	100·08

11. Faujasite.

This species, which has been briefly alluded to in the preceding note, as being one of the mineral associations of the datolite found at the Daisy mica mine, on the ninth lot of the first range of the township of Derry, Ottawa county, in the province of Quebec, is there met with in the form of simple octahedral crystals implanted upon the walls of small cavities in the quartz or intimately associated with the fluorite, both of which enter largely into the composition of the matrix of the datolite. The crystals vary in size from such as are of almost microscopic minuteness to others having a diameter of about two millimetres. They are mostly milk-white—with, in some instances, a faint greenish tinge, in colour, and opaque, occasionally, however, colourless and translucent, and have a vitreous lustre. In the closed tube the mineral yields much water. Before the blowpipe, it intumesces and fuses to a white blebby enamel. It is decomposed by hydrochloric acid without gelatinization.

MINERALOGICAL NOTES.

1.—Allophane. A pale bluish-white allophane, having a waxy lustre, has been recognized by Mr. R. A. A. Johnston, as filling small fissures in specimens of light yellowish-gray andradite occurring at the Rabbit-foot claim on the White Horse copper-belt, on the west side of Lewes river, opposite White Horse and Miles canyon, Yukon district, North-west Territory. Before the blowpipe it falls to pieces, and is infusible; when moistened with a solution

of cobalt nitrate, and again ignited, it assumes a blue colour. In the closed tube it gives off a large amount of water. It is decomposed by hydrochloric acid with separation of gelatinous silica.

2.—Altaite. Small quantities of a massive altaite have been recognized as occurring, with chalcopyrite and particles of native gold, scattered through some specimens of quartz, collected by Mr. J. McEvoy, from a narrow quartz vein at the Pay Roll claim, on Little Nigger creek, twelve miles south-west of Cranbrook, East Kootenay district, province of British Columbia.

3.—Amazonstone. Fine cleavable masses of a verdigris-green, passing into white, microcline, have been obtained by Mr. A. P. Low, from pegmatite veins cutting schistose traps on some of the islands of the Paint Hills group, east coast of James bay, Ungava district, North-east Territory.

4.—Barite. A white fine granular, and ash-gray coarse crystalline, massive barite, has been met with, in Lower Trenton limestone, on the twenty-seventh lot of the seventh concession of the township of Huntley, Carleton county, in the province of Ontario.

5.—Celestite. Among other specimens collected by Dr. R. Bell in the course of his geological examination of the Manitoulin islands in 1865, were some very good specimens, recently handed to me, of celestite found by him in the Hudson River formation on the east side of Manitouaning bay and at Cape Robert, Grand Manitoulin island, and west south-west of Cape Robert on Bayard island, a small island lying about a mile off shore. In these specimens, the mineral occurs in the form of white, at times, in part, bluish, translucent, radiating fine columnar masses with yellow to white, translucent, rhombohedral crystals of dolomite, inclosed in a very fine granular, light bluish-gray, compact magnesian limestone.

6.—Chrysocolla. Small quantities of a greenish-blue chrysocolla, together with some limonite and a little green carbonate of copper, have been observed incrusting specimens of a light yellowish-gray granite, collected by Mr. R. G. McConnell, from the west wall of the Pueblo claim on the White Horse copper-belt, west side of Lewes river, opposite White Horse and Miles canyon, Yukon district, North-west Territory.

7.—Danaite. Fairly well-developed, at times perfect, crystals of danaite —one of the latter of which measured nearly two millimetres in the direction of the longer axis, have been observed by Mr. R. A.

A. Johnston, distributed through a crystalline granular, massive, cobaltiferous arsenopyrite which occurs, associated with a nickeliferous pyrrhotite, niccolite, and chalcopyrite, in a gangue composed of a dark gray calcareous mica-diorite gneiss, on the twelfth lot of the ninth range of the township of Calumet, Pontiac county, in the province of Quebec.

8.—Epidote. This mineral has been met with by Mr. A. P. Low, in considerable abundance, as a rock constituent, on the north-east part of Walrus island—one of the Paint Hills group, off the east coast of James bay, Ungava district, North-east Territory—which, as I am informed by Mr. Low, is occupied by a porphyritic augite-syenite, composed largely of felspar in a ground mass of dark green augite, cut by a large dyke of diabase which at, and for upwards of a hundred feet from its contact with the syenite, has effected an alteration of the augite of the latter to epidote, thereby converting the augite-syenite into an epidote-syenite. Some of the finest specimens of the mineral collected by Mr. Low were obtained in close proximity to the dyke. These consist of interlaced radiating crystalline aggregates of a light to dark yellowish-green epidote filling cavities in large cleavable masses of tile-red orthoclase.

9.—Erythrite. Earthy cobalt bloom, of a peach blossom colour, has been observed coating the surfaces of fine fissures in specimens of a gray felspathic rock, collected by Mr. J. McEvoy, carrying small quantities of magnetite, at the Chickamon-stone claim, on the west side of Bull river—a tributary of the Kootenay, about a mile above the old pack bridge, in the East Kootenay district of the province of British Columbia. Fleckings of a cochineal-red erythrite have also been observed on some specimens of a light gray massive grossularite, collected by Mr. McConnell, which enters largely into the composition of the gangue of the Cornite at the Rabbit-foot claim on the White Horse copper belt, west side of Lewes river, opposite White Horse and Miles canyon, Yukon district, North-west Territory.

10.—Galena. Fine groups of cubic crystals of galena—the latter, in some instances, measuring four centimetres across, as likewise groupings of smaller cubo-octahedral crystals, more or less coated, however, with lead carbonate intermixed with a little lead sulphate, have occasionally been met with in a galena-bearing vein, having a gangue of calc-spar mingled with some heavy-spar, traversing the crystalline limestone of the Laurentian series on the

eighteenth lot of the eighth concession of the township of Bedford, Frontenac county, province of Ontario.

11.—Gmelinite. This species has been met with in reddish-white, well-formed, translucent crystals of rhombohedral habit, in the workings of the War Eagle mine, which is located on a spur of Red mountain, about half a mile north-north-west of the town of Rossland, in the West Kootenay district of the province of British Columbia.

12.—Graphite. A large deposit of graphite intermingled with calcite, dolomite, quartz, and actinolite—a specimen of which was found to contain 64·3 per cent of graphite, occurs forming a vein, as it has been described, of from four to eight feet in width, cutting a crystalline limestone, on the north shore of Birch lake, that is to say on the first lot of the fifth concession and extending thence, in a north-easterly direction, into the second lot of the sixth concession, of the township of Bedford, Frontenac county, in the province of Ontario. Another deposit of graphite, a sample of the material of which was found to contain 77·6 per cent of graphite, has been met with on the twenty-second lot of the second concession of the township of South Canonto, also in Frontenac county.

13.—Hematite. Has been met with by Mr. J. M. Bell, in reniform masses, having a finely fibrous structure—pseudomorph after limonite, intimately associated with a compact, also, at times, a lamellar and micaceous, hematite, forming a vein of from two to three feet or more in width, which traverses a dark red, highly felspathic, vesicular trap composing Rocher Rouge, MacTavish bay, east side of Great Bear lake, Mackenzie district, North-west Territory.

14.—Hematite, Micaceous. A dark, steel-gray, schistose aggregate of micaceous hematite and grayish-white, translucent quartz—micaceous iron-schist, has been found by Mr. J. M. Bell, forming lenticular veins, one of which had a maximum width of twenty feet, and stringers, in a greenish siliceous sandstone, on some of the more southerly of the group of islands known as Les Iles du Large, Great Slave lake, district of Mackenzie, North-west Territory.

15.—Hematite, var. specular iron. This has been met with by Mr. J. M. Bell, in some abundance, at Echo bay, on the east side of Great Bear lake, district of Mackenzie, in the North-west Ter-

ritory. A very large deposit of a crystalline massive specular iron, holding small quantities of intermixed green carbonate of copper, has likewise been met with, according to Mr. R. G. McConnell—who collected the specimens examined, at the Pueblo claim, on the White Horse copper-belt, west side of Lewes river, opposite White Horse and Miles canyon, Yukon district, North-west Territory.

16.—Hydromagnesite. This species has been found by Mr. J. M. Bell—to whom the writer is indebted for the specimens examined, in the form of white, sometimes superficially pinkish, amorphous incrusting masses, having a more or less botryoidal structure, on the upper surfaces of cavities in an exposure of dark, porous, highly weathered dolomite, constituting, in part, high cliffs on the south shore of Dease bay, some thirty miles south-west of Fort Confidence, Great Bear lake, Mackenzie district, North-west Territory.

17.—Jamesonite. Fine specimens of a fibrous massive jamesonite have been obtained by Mr. R. W. Brock, at the David Whitley or Red Paddy claim, at the head of Kettle river, Yale district, in the province of British Columbia, where it occurs, with native gold, in a gangue of white subtranslucent quartz.

18.—Magnesite. Large exposures of magnesite rock, associated with serpentines, have been met with by Mr. J. C. Gwillim, in the vicinity of Atlin, on the east side of Atlin Lake, Cassiar district, in the province of British Columbia. Specimens of this rock, collected by Mr. Gwillim, from Discovery claim, on Pine creek, and from the Anaconda group of claims on the Indian reserve, Atlin city, have been examined and found to consist—that from the first mentioned locality, of an association of a white crystalline ferriferous magnesite with a little white translucent quartz, through which is distributed a few fine scaly aggregations of a bright green chromiferous muscovite, and that from the last mentioned locality, of an intimate admixture of a light yellowish-grayish crystalline ferriferous magnesite and white quartz, sometimes galena-bearing, through which are scattered small grains of pyrite and magnetite and, occasionally, some fine scaly aggregations of the above mentioned chromiferous mica.

Some fine specimens of a snowy-white, compact massive magnesite, have also been handed to the writer by Mr. Gwillim, which he found forming a vein of some seven inches or more in width,

cutting weathered slates, about a mile north of Pike river, on the eastern side of the southern end of Atlin lake, referred to above. This magnesite contains but a small proportion (amounting, in the specimen examined, to not more than ten per cent) of foreign admixture consisting of white quartz, which, on removal of the magnesium carbonate by treatment with acid, remains behind in a highly cellular, easily crumbled, skeleton form.

19.—Magnetite. Large bodies of a fine granular, massive magnetite, through which is disseminated a little chalcopyrite, have been met with, according to Mr. R. G. McConnell, at the Arctic Chief and Valerie claims on the White Horse copper-belt, on the west side of Lewes river, opposite White Horse and Miles canyon, Yukon district, North-west Territory.

20.—Marl. A deposit of comparatively pure shell-marl, having an area of some twenty acres and a depth of from three to six feet, has been found on the west half of the tenth lot of the first concession of the township of Stafford, Renfrew county, in the province of Ontario; and in the immediate vicinity of this deposit there is another of probably not less than five hundred acres in extent and having a thickness of from three to eight feet, which is for the greater part overlaid—in some places to a depth of five feet—by swamp-muck.

21.—Micaceous hematite. See hematite, micaceous, No. 14.

22.—Molybdenite. Good specimens of this mineral have been obtained by Mr. A. P. Low from a vein of pegmatite cutting the trap on island No. 12 of the Paint Hills group, off the east coast of James bay, Ungava district. In these the mineral occurs in foliated masses and in crystalline plates having a more or less perfect hexagonal outline, the largest of which measures twenty-five millimetres across, imbedded in a reddish felspar and grayish-white subtranslucent quartz. It has also been met with in large foliated masses, associated with pyrite, on the sixteenth lot of the first concession of the township of Brougham, Renfrew county, in the province of Ontario; and specimens of an exceptionally bright bluish-gray, fine-granular, massive molybdenite, have been obtained by Mr. R. W. Brock, at the Giant claim, Trail Creek mining area, in the West Kootenay district of the province of British Columbia, where it occurs with galena, pyrrhotite, chalcopyrite and arsenopyrite, in masses up to and exceeding a foot in diameter.

23.—Monazite. Several well-formed crystals of this mineral have recently been found by Mr. R. L. Broadbent in the coarse pegmatite vein occurring on lot thirty-one, and adjoining lots, of the first range of the township of Villeneuve, Ottawa county, in the province of Quebec. Some of these crystals occur imbedded in albite, others in tourmaline, and yet others partly in the albite and partly in the tourmaline. The largest is a short stout clove-brown crystal, measuring sixteen by thirteen by six millimetres in its diameters, twinned about the basal plane and exhibiting a distinct basal cleavage and a small subconchoidal fracture.

24.—Mountain leather. This has been found in some little quantity in narrow, more or less vertical, fissures of from less than an inch to four or five inches in width, in Triassic sandstones on the shore on the west side of the harbour, near the village of Lower Five islands, township of Economy, Colchester county, in the province of Nova Scotia.

25.—Sericite. A sample of the material constituting what is known as the 'quartz-drift,' from a deposit of the same on Bonanza creek, a tributary of the Klondike, Yukon district, North-west Territory, handed to me by Mr. R. G. McConnell on his return from a geological examination of the Klondike area, was found to consist of a firmly compacted mass composed of minute light yellowish-gray pearly scales of sericite, very fine to moderately coarse, angular grains of colourless transparent to white translucent quartz, some of which latter exhibited a faint bluish opalescence, and rounded fragments of sericite-schist, together with a few particles of native gold. The fine scaly sericite constituting, the specimen examined, 29·4 per cent of the whole.

26.—Siderite. A coarse crystalline, massive, clove-brown, magnesian siderite has been found by Mr. J. M. Bell, in some little quantity, associated with quartz and calc-spar, forming stringers in a bed of dolomite, on the south shore of Dease bay, Great Bear lake, about twenty-eight miles south-west of the site of Fort Confidence, or nearly opposite the Narakay islands (Les Iles Hautes), as likewise and under the same conditions at a point some two miles further south-west of this locality, in the district of Mackenzie, North-west Territory.

27.—Silver, native. Some very handsome specimens of native silver have been found by Mr. McInnes, associated with argentite and sphalerite, in the silver-bearing vein at the West-end mine, Silver

mountain, township of Lybster, district of Thunder bay, province of Ontario. They consist of sheets of an arborescent form of the mineral of some seven by eight centimetres across and about half a millimetre in thickness, as likewise of plates of the same, of similar dimensions.

28.—Specular iron. See hematite, var. specular iron, No. 15.

29.—Spessartite. Fine specimens of this mineral have been handed to me by Mr. C. W. Willimott, which were given to him by a prospector who found them, associated with magnetite, et cetera, in a coarse pegmatite vein occurring in the township of Proudfoot, Parry Sound district, province of Ontario. They consist of dark brownish-red, compound rhombic dodecahedral crystals measuring from two or three up to as much as forty-five millimetres in diameter.

30.—Sphalerite. This mineral has been met with somewhat plentifully distributed through mica-schist, on the forty-first and forty-second lots of the first and second ranges of the township of Bouchette, Ottawa county, in the province of Quebec.

31.—Stibnite. Small quantities of stibnite have been observed distributed through specimens of the massive garnet (grossularite), collected by Mr. R. G. McConnell, which accompanies the bornite at the Copper King and Anaconda claims on the White Horse copper-belt, west side of Lewes river, opposite White Horse and Miles canyon, Yukon district, North-west Territory.

32.—Wilsonite. Small masses of a pale peach-blossom red wilsonite have occasionally been found (as exemplified by specimens collected by Mr. McConnell), associated with grossularite, dolomite, tremolite, quartz and a little serpentine, accompanying the bornite at the Rabbit-foot claim on the White Horse copper-belt, west side of Lewes river, opposite White Horse and Miles canyon, Yukon district, North-west Territory.

COALS AND LIGNITES.

(Continued from page 11R of the Annual Report of this Survey for 1896.)

91.—Lignite. From the upper seam on Coal creek, aneasterly branch of Rock creek which is a tributary of the Klondike river, Yukon

district, North-west Territory. Thickness of seam, three feet. Geological position—Tertiary. Received from Mr. W. Ogilvie.

Structure, fine lamellar, compact; colour, black; lustre, dull; fracture, uneven; contains, in parts, particles of brownish-yellow sub-transparent resin; by exposure to the air becomes somewhat fissured and in consequence has a tendency to fall to pieces; does not soil the fingers; powder, brownish-black; it communicates a dark brownish-red colour to a boiling solution of caustic potash.

An analysis by fast coking, gave:

Hygroscopic water	18·31
Volatile combustible matter	34·96
Fixed carbon	40·88
Ash	5·85
	100·00
Coke, per cent	46·73
Ratio of volatile combustible matter to fixed carbon	1 : 1·17

It yields by fast coking, a non-coherent coke. The gases evolved during coking burn with a yellowish, slightly luminous, almost smokeless flame. The ash has a dark-brown colour—exposed to a bright red heat it becomes slightly agglutinated, at a most intense red heat it forms a vitrified mass.

92.—Lignite. From the lower seam on Coal creek, above referred to. Thickness of seam, two to three feet. The two seams are separated by a clay parting about a foot thick and are roofed and floored with clay. Received from Mr. W. Ogilvie.

Structure, fine lamellar, compact; colour, velvet black; lustre, dull to sub-resinous; fracture, uneven, occasionally subconchoidal; does not soil the fingers; by exposure to the air it becomes more or less fissured and has a tendency to fall to pieces; powder, brownish-black; it communicates a deep brownish-red colour to a boiling solution of caustic potash.

An analysis by fast coking, gave:

Hygroscopic water	19·37
Volatile combustible matter	33·85
Fixed carbon	37·45
Ash	9·33
	100·00
Coke, per cent	46·78
Ratio of volatile combustible matter to fixed carbon	1 : 1·11

It yields by fast coking, a non-coherent coke. The gases evolved during coking burn with a yellowish, somewhat luminous, smokeless flame. The ash has a yellowish-red colour—exposed to a bright red heat it becomes very slightly agglutinated, at a most intense red heat it fuses to a slaggy mass.

93.—Lignite. From upper working on Cliff creek, about two and three-quarter miles up from its mouth, a tributary of the Yukon, Yukon district, North-west Territory. Geological position—Tertiary. Collected by Mr. R. G. McConnell.

Structure, on the whole, compact; made up of a very finely laminated—yet not always very distinctly so, grayish-black, dull coal, with interposed, more or less disconnected, lenticular layers of dense, jet black, highly lustrous coal; fracture, uneven, that of the bright layers, subconchoidal to conchoidal; is hard and firm; does not soil the fingers; contains, in parts, a large quantity of brownish-yellow resin diffused through its substance, and, here and there, a few films of pyrite; colour of powder, black with a faint brownish tinge; it communicates a dark brownish-red colour to a boiling solution of caustic potash.

An analysis by fast coking, gave:

Hygroscopic water	8·57
Volatile combustible matter	42·04
Fixed carbon	45·77
Ash	3·62
	100·00
Coke, per cent	49·39
Ratio of volatile combustible matter to fixed carbon	1 : 1·09

It yields, by fast coking, a feebly coherent, tender coke. The gases evolved during coking burn with a yellow luminous, smoky flame. The ash has a reddish-brown colour; this, when exposed to a bright red heat becomes slightly agglutinated, and at a most intense red heat forms a more or less vitrified mass.

94.—Lignite. From lower working on Cliff creek, about two and one-third miles up from its mouth, a tributary of the Yukon, Yukon district, North-west Territory. Collected by Mr. R. G. McConnell.

Structure, very fine lamellar—the lines of bedding are, however, often almost obliterated,—compact; colour, black; lustre, subresinous to resinous; fracture, uneven, at times subconchoidal;

hard and firm; does not soil the fingers; is here and there intersected by delicate films of pyrite; colour of powder, black with a faint brownish tinge; it communicates a dark brownish-red colour to a boiling solution of caustic potash.

An analysis by fast coking gave:

Hygroscopic water	10·58
Volatile combustible matter	40·10
Fixed carbon	46·74
Ash	2·58
	100·00
Coke, per cent	49·32
Ratio of volatile combustible matter to fixed carbon	1 : 1·16

It yields, by fast coking, a non-coherent coke. The gases evolved during coking burn with a yellow, luminous, smoky flame. The ash has a light brownish-yellow colour; this, when exposed to a bright red heat becomes slightly agglutinated, and at a most intense red heat forms a vitrified mass.

95.—Lignitic coal. From a seam on Lewes river, about six miles above Rink rapid ('Five Fingers' of miners), Yukon district, Northwest Territory. Taken some forty feet in from the outcrop, at which point the seam was found to have a thickness of about two feet and a half. Geological position—Laramie. Received from Mr. W. Ogilvie.

Structure, fine lamellar—compact; colour, grayish-black; lustre, resinous; hard and firm; fracture, uneven; it is, here and there, intersected by a few films of calcite; does not soil the fingers; powder, brownish-black; it communicates a brownish-yellow colour to a boiling solution of caustic potash.

An analysis by fast coking gave:

Hygroscopic water	6·42
Volatile combustible matter	36·98
Fixed carbon	46·03
Ash	10·57
	100·00
Coke, per cent	56·60
Ratio of volatile combustible matter to fixed carbon	1 : 1·24

It yields, by fast coking, a very slightly fritted coke. The gases evolved during coking burn with a yellow, luminous, somewhat smoky flame. The ash has a dull reddish-brown colour—

exposed to a bright red heat it does not agglutinate, at a mos intense red heat it readily fuses to a vitrified mass.

96.—Coal. From a seam, described by the sender as being 'sixteen feet in thickness, with twelve feet of solid coal,' on Collins gulch, Tulameen river, about eighteen or twenty miles west of Princeton, Yale district, province of British Columbia. Received from Mr. Geo. de Wolf.

Structure somewhat fine to coarse lamellar, more or less highly contorted; colour, grayish-black; lustre, dull to subresinous; fracture, irregular, that of some of the denser layers, at times, subconchoidal; is firm; does not soil the fingers; contains, here and there, a few films of pyrite; colour of powder, black with a faint brownish tinge; it communicates a brownish-red colour to a boiling solution of caustic potash.

An analysis by fast coking gave:

Hygroscopic water	4·62
Volatile combustible matter	41·16
Fixed carbon	49·04
Ash	5·18
	100·00
Coke, per cent	54·22
Ratio of volatile combustible matter to fixed carbon	1 : 1·19

It yields, by fast coking, a firm coherent coke. The gases evolved during coking burn with a yellow, luminous, very smoky flame. The ash, which has a light gray colour, does not agglutinate at a bright red heat, and at a most intense red heat becomes only slightly fritted.

97.—Coal. From a seam, described by the sender as having 'a thickness of twenty feet, with seams of from two feet six inches to four feet eight inches of clean coal,' on Collins gulch, Tulameen river—same locality as that referred to under No. 96. Received from Mr. Geo. de Wolf.

Structure, lamellar, the lines of bedding are, however, often indistinct; colour, grayish-black; lustre, subresinous to resinous; is firm; does not soil the fingers; fracture, uneven; colour of powder, black with a faint brownish tinge; it communicates a brownish-red colour to a boiling solution of caustic potash.

An analysis by fast coking, gave:

Hygroscopic water	4·87
Volatile combustible matter	36·86
Fixed carbon	50·99
Ash	7·28
	100·00
Coke, per cent	58·27
Ratio of volatile combustible matter to fixed carbon	1 : 1·38

It yields, by fast coking, a coherent but tender coke. The gases evolved during coking burn with a yellow, luminous, smoky flame. The ash, which is of a light gray colour, does not agglutinate at a bright red heat, and at a most intense red heat becomes only slightly fritted.

98.—Coal. From a seam on the Stony Indian reserve, about two miles south of Morley station on the line of the Canadian Pacific railway, district of Alberta, North-west Territory. Seam said to be six feet thick. Received from Mr. W. Pearce.

It has a crumpled laminated structure; shows slickensides; is moderately firm; colour, grayish-black to black; lustre, resinous to vitreous; fracture, irregular; powder, black with a faint brownish tinge; it communicates a faint brownish-yellow colour to a boiling solution of caustic potash.

An analysis by fast coking, gave:

Hygroscopic water	1·26
Volatile combustible matter	41·30
Fixed carbon	48·60
Ash	8·84
	100·00
Coke, per cent	57·44
Ratio of volatile combustible matter to fixed carbon	1 : 1·18

It yields, by fast coking, a compact, firm, coherent coke. The gases evolved during coking burn with a yellow, luminous, very smoky flame. The ash, which is of a light reddish-brown colour, when exposed to a bright red heat becomes slightly agglutinated, and at a most intense red heat forms a more or less vitrified mass.

99.—Anthracite. From a seam about ten miles west of Dugdale station, on the line of the White Pass and Yukon railway, Yukon district, North-west Territory. Collected by Mr. R. G. McConnell

Structure, foliated, highly crumpled; contains occasional interposed patches of mineral charcoal; colour, grayish-black to black; lustre, dull to brilliant; is brittle; fracture, uneven; the brighter portions do not soil the fingers; powder, grayish-black; it communicates a faint brownish-yellow colour to a boiling solution of caustic potash.

An analysis by fast coking, gave:

Hygroscopic water	2·31
Volatile combustible matter	5·59
Fixed carbon	67·20
Ash	24·90
	100·00
Coke, per cent	92·10
Ratio of volatile combustible matter to fixed carbon	1 : 12·05

It yields, by fast coking, a non-coherent coke. The gases evolved during coking burn with a very faintly yellowish, smokeless flame of feeble luminosity. Colour of the ash, very light reddish-brown; this, when exposed to a bright red heat becomes very slightly agglutinated, and at a most intense red heat becomes fritted.

LIMESTONES AND DOLOMITES.

(Continued from page 21R of the last Annual Report of this Survey—vol. XI., 1898.)

1.—Limestone. From the Messrs. Rokes and Morse's quarry on Drury cove, Kennebecasis river, about four miles from its mouth and about half a mile to the westward of Lawlors lake, parish of Portland, St. John county, province of New Brunswick.

A light bluish-gray, crypto-crystalline, massive limestone, traversed by numerous very thin layers of a yellowish-gray earthy mineral which, owing to insufficiency of material, was not identified. An analysis, by Mr. F. G. Wait, showed it to have the following composition:

(After drying at 100° C.—Hygroscopic water = 0·03 per cent.)

Carbonate of lime			96·55
" magnesia			0·76
" iron			0·11
" manganese			trace.
Alumina	0·01		
Silica, soluble	0·03		2·72
Insoluble mineral matter	2·68		
			100·14

This stone affords an excellent lime.

2.—Limestone. This, and the two following stones represent the material of three of the more important beds (here referred to in descending order) at Messrs. H. Robillard and Son's quarry on the twenty-second lot of the first concession of Ottawa Front, township of Gloucester, Carleton county, province of Ontario. Geological position—Trenton formation, Cambro-silurian.

Stone from the first bed. Thickness of the same, eighteen to twenty-four inches. Structure, moderately fine-crystalline ; colour, dark gray. Its composition was found by Mr. Wait, to be as follows :

(After drying at 100° C.—Hygroscopic water = 0·03 per cent.)

Carbonate of lime			97·87
" magnesia			1·13
Phosphate of lime (tribasic)	0·39*		
Alumina	0·04		
Silica, soluble	0·05		1·28
Bisulphide of iron	0·13†		
Insoluble mineral matter	0.59		
Organic matter	0·08		
			100·28

This stone is extensively quarried for structural purposes.

3.—Stone from the third bed of Messrs. H. Robillard and Son's quarry. This bed has a thickness of from fifteen to twenty inches. Structure, fine-crystalline ; colour, light gray. An analysis by Mr. Wait, afforded the following results :

* Corresponding to 0·079 phosphorus. † Corresponding to 0·07 sulphur.

(After drying at 100° C.—Hygroscopic water = 0·04 per cent.)

Carbonate of lime			98·25
" magnesia			0·78
Phosphate of lime (tribasic)	0·37*		
Alumina	0·04		
Silica, soluble	0·02		
Bisulphide of iron	0·06†		1·13
Insoluble mineral matter	0·60		
Organic matter	0·04		
			00 16

This stone is largely used for building purposes.

4.—Stone from the fifth bed of Messrs. H. Robillard and Son's quarry.

Thickness of the bed, twelve to twenty inches. Structure, somewhat coarse-crystalline; colour, faintly brownish light gray.

An analysis by Mr. Wait, gave as follows:

(After drying at 100° C.—Hygroscopic water = 0·06 per cent.)

Carbonate of lime			98·68
" magnesia			0·90
Phosphate of lime (tribasic)	0·17‡		
Alumina	0·17		
Silica, soluble	0·02		
Bisulphide of iron	0·04§		0·73
Insoluble mineral matter	0·32		
Organic matter	0·01		
			100·31

This stone is employed for building purposes.

5.—Limestone. This, and the two following stones represent the material of three of the beds worked at a quarry on the eighth lot of the first concession of the township of Colborne, Huron county, province of Ontario. They were examined for Mr. Alex. McD. Allan.

Stone from the fourth bed or layer occurring at the quarry in question. Thickness of the band, about six inches—more or less.

An ashy-brown, very fine-crystalline, almost compact limestone.

* Corresponding to 0·074 phosphorus. † Corresponding to 0·03 sulphur.
‡ Corresponding to 0·035 phosphorus. § Corresponding to 0·02 sulphur.

Its analysis afforded Mr. Wait the following results:

(After drying at 100° C.—Hygroscopic water=0·06 per cent.)

Carbonate of lime			95·57
" magnesia			2·77
" iron			0·31
" manganese			trace.
Alumina	0·01		
Silica, soluble	0·04		
Insoluble mineral matter	1·30		1·62
Organic matter	0·27		
			100·27

6.—Stone from the thirteenth bed or layer of the quarry from which the preceding specimen was taken. Thickness of the band, about three inches—more or less.

A yellowish-brown, fine-crystalline, dolomitic limestone. An analysis, by Mr. Wait, showed it to have the following composition:

(After drying at 100° C.—Hygroscopic water = 0·04 per cent.)

Carbonate of lime			81·75
" magnesia			15·06
" iron			0·72
" manganese			trace
Alumina	0·11		
Silica, soluble	0·02		2·78
Insoluble mineral matter	2·57		
Organic matter	0·08		
			100·31

7.—Stone from the twenty-fourth bed or layer of the quarry from which the two preceding specimens were taken. The thickn es of the band, about six inches—more or less.

A light yellowish-brown, fine to moderately coarse-crystalline, somewhat magnesian limestone. Its composition was found, by Mr. Wait, to be as follows:

(After drying at 100° C.—Hygroscopic water = 0·03 per cent.)

Carbonate of lime			91·46
" magnesia			6·22
" iron			0·48
" manganese			trace
Alumina	0·06		
Silica, soluble	0·02		1·87
Insoluble mineral matter	1·74		
Organic matter	0·05		
			100·03

8.—Dolomite. From the sixteenth lot of the sixth concession of the township of Ross, Renfrew county, province of Ontario. Geological position—Laurentian. Examined for Mr. W. P. Hinton.

A beautiful, white, translucent, coarsely crystalline dolomite.

Its analysis afforded Mr. Wait the following results:

(After drying at 100° C.—Hygroscopic water = 0·03 per cent.)

Carbonate of lime		55·32
" magnesia		44·54
" iron		0·11
" manganese		trace
Phosphate of lime (tribasic)	0·02*	0·47
Alumina	0·09	
Silica, soluble	0·17	
Insoluble mineral matter	0·19	
		100·44

IRON ORES.

1.—Hematite. From the Arisaig district, Antigonish county, province of Nova Scotia, in which locality there occurs an extensive deposit of a dark-reddish-brown to blackish-brown oölitic hematite, upon which numerous trial pits have been sunk on the East Branch of Doctors brook and on its tributaries Iron and McInnes brooks.

(*a.*) A fair average sample of the material from four trial pits on or near Campbell's brook, a tributary of the East Branch of Doctors brook, was found by Mr. Wait to contain:

Metallic iron	44·75	per cent.
Phosphorus	0·84	"
Sulphur	0·008	"
Insoluble matter	25·76	"

(*b.*) A fair average sample of the material from eight trial pits on or in close proximity to Iron brook, was found by Mr. Wait to contain:

Metallic iron	45·30	per cent.
Phosphorus	0·60	"
Sulphur	0·003	"
Insoluble matter	26·33	"

* Corresponding to 0·004 phosphorus.

(*c.*) A fair average sample of the material from five trial pits on or near McInnes brook, was found by Mr. Wait to contain:

Metallic iron	48·77	per cent.
Phosphorus	0·42	"
Sulphur	none	"
Insoluble matter	22·56	"

2.—Hematite. From a vein at Rocher Rouge, MacTavish bay, East side of Great Bear lake, Mackenzie district, North-west Territory. Collected by Mr. J. M Bell.

A fibrous, botryoidal, and micaceous hematite, associated with some quartzite. Determinations by Mr. Wait gave:

Metallic iron	44·17	per cent.
Insoluble matter	28·92	"

3.—Hematite. A granular schistose aggregate of quartz and micaceous iron—micaceous iron-schist, has been met with, forming lenticular veins and stringers in a greenish siliceous sandstone, on some of the more southerly of the group of islands known as Les Iles du Large, Great Slave lake, district of Mackenzie, North-west Territory. A specimen of this ore, collected by Mr. J. M. Bell, has been examined by Mr. Wait and found to contain:

Metallic iron	64·35	per cent.
Insoluble matter	6·66	"

4.—Limonite. From the Grand River barrens, one mile south-west of Grand River falls, Richmond county, province of Nova Scotia. Examined for Mr. James MacIntosh.

A massive, compact and lustreless, hair-brown limonite. A partial analysis afforded Mr. Wait as follows:

Metallic iron	59·89	per cent.
Phosphorus	0·375	"
Sulphur	none.	
Insoluble matter	0·98	"

5.—Magnetite. From a deposit on the Old French road, two miles easterly of the Mira Roman Catholic chapel, Cape Breton county, province of Nova Scotia. Examined for Mr. Patrick MacMillan.

A very fine-granular, compact, massive, dark gray, somewhat siliceous, magnetite, which on examination by Mr. Johnston was found to contain:

Metallic iron	61·45	per cent.

NICKEL AND COBALT.

Estimation of, in certain ores from the undermentioned localities in the provinces of Quebec, Ontario, and British Columbia and the district of Ungava. Continued from page 41R of the Annual Report of this Survey (vol. XI.), for 1898.

1.—From a small island off the west point of Kogaluk river, east coast of Hudson bay, Ungava district.

A massive pyrrhotite, through which was distributed a large amount of white cryptocrystalline quartz. Weight of sample, two pounds eleven ounces. A fair average of this was found, by Mr. R. A. A. Johnston, to contain:

Nickel, with some cobalt.....	0·08 per cent.

The gangue constituted 48·00 per cent, by weight, of the whole. The metalliferous portion of the ore contained, therefore, 0·15 per cent of nickel, with some cobalt.

2.—From the fourteenth lot of the fifth range of the township of Masham, Ottawa county, province of Quebec.

A massive pyrite, through which was distributed a few particles of copper-pyrites, in association with a somewhat large proportion of gangue—consisting of a fine-grained granite. The pyrite, freed from all gangue, was found by Mr. F. G. Wait to contain:

Cobalt, with a little nickel.	0·28 per cent.

3.—From the township of Matawatchan, Renfrew county, province of Ontario.

A compact, massive pyrrhotite, with which was associated a small quantity of gangue—composed of white translucent quartz and hornblendic-gneiss. The pyrrhotite, freed from all gangue, was found by Mr. Wait to contain:

Nickel.....	0·29 per cent.
Cobalt.....	trace.

4.—From the north-east quarter section of block 1, on the west side of Texada island, province of British Columbia. Examined for Mr. Alfred Raper.

A very fine-granular, massive pyrrhotite. It was found by Mr. Johnston to contain :

Nickel..... ..... faint traces.

5.—From near Kyuquot, west coast of Vancouver island, province of British Columbia. Examined for Mr. G. H. Franklin.

A granular, massive pyrrhotite, with which was associated a very little copper-pyrites and a small quantity of quartzose gangue. Mr. Wait found it to contain :

Nickel .... trace.

GOLD AND SILVER ASSAYS.

These were all conducted by Mr. R. A. A. Johnston.

As explanatory of the numerous instances in which no trace of either gold or silver was found, it may be mentioned that in nearly all these cases the assay was carried out by special request.

Province of New Brunswick.

1.—From one of several large quartz veins found on Biggar ridge, in the parish of Aberdeen, Carleton county.

An association of a dark greenish-gray felspathic rock with a white to reddish coloured quartz, carrying small quantities of copper-pyrites and a little galena and pyrrhotite. The sample consisting of five fragments, weighed nine pounds seven ounces. It was found to contain :

Gold.....none.
Silver.....0·583 of an ounce to the ton of 2,000 lbs.

2.—From Beaufort, Carleton county. Examined for Mr. George Bailey.

An association of white crystalline quartz with some greenish-gray chloritic mineral matter, in parts coated with green carbonate of copper, carrying small quantities of iron pyrites, copper-pyrites and galena. The sample, consisting of eight fragments, weighed twelve ounces. Assays gave :

Gold.....trace.
Silver... .....0·583 of an ounce to the ton of 2,000 lbs.

Province of Quebec.

3.—From a small island south of the mouth of East Main river, east coast of James Bay. Collected by Mr. A. P. Low.

A brownish-black hornblende-schist, carrying small quantities of pyrrhotite. The sample, a single fragment, weighed twelve ounces.

It contained neither gold nor silver.

Ungava District.

4.—From one of the Solomon Temple islands, east coast of James bay. This, and the fourteen following specimens were collected by Mr. A. P. Low.

A massive iron-pyrites, coated with hydrated peroxide of iron. The sample, a single fragment, weighed two pounds six ounces. It contained :

Gold .....none.
Silver.....0·175 of an ounce to the ton of 2,000 lbs.

5.—From the south point of the mouth of Great Whale river, east coast of Hudson bay.

A gray quartzo-felspathic rock, carrying large quantities of iron-pyrites. The sample, consisting of six fragments, weighed six ounces. It was found to contain :

Gold.....none.
Silver... .....0·175 of an ounce to the ton of 2,000 lbs.

6.—From Cape Hope island, east coast of James bay.

An association of white translucent quartz with a little greenish-gray chloritic schist, carrying small quantities of iron-pyrites. The sample, a single fragment, weighed nine ounces.

It contained neither gold nor silver.

7.—From the south side, near outlet, of Richmond gulf, east coast of Hudson bay.

A massive iron-pyrites, more or less thickly coated with hydrated peroxide of iron. The sample, a single fragment, weighed seven ounces. It contained :

Gold..... ..... none.
Silver.....0·350 of an ounce to the ton of 2,000 lbs.

8.—From the west point of mouth of Kogaluk river, east coast of Hudson bay.

A white to grayish-black quartz-syenite. The sample, a single fragment, weighed fourteen ounces.

It contained neither gold nor silver.

9.—From a small island off the west point of Kogaluk river, east coast of Hudson bay.

Pyrrhotite. through which was distributed a somewhat large amount of white crypto-crystalline quartz. The sample, a single fragment, weighed two pounds eleven ounces.

It contained neither gold nor silver.

10.—From Cape Wolstenholme, east coast of Hudson bay.

A weathered gneissoid rock, carrying small quantities of pyrrhotite. The sample, a single fragment, weighed four ounces.

It contained neither gold nor silver.

11.—From a small island lying off Cape Anderson, east coast of Hudson bay.

A bluish to grayish-white translucent quartz. The sample, a single fragment, weighed four ounces.

It contained neither gold nor silver.

12.—From a small island ten miles north of Portland promontory, east coast of Hudson bay.

A dark gray granitic gneiss, coated with hydrated peroxide of iron. The sample, a single fragment, weighed one pound six ounces.

It contained neither gold nor silver.

13.—From the same locality as the preceding specimen.

An association of bluish-white translucent quartz with a little black hornblende, through which was distributed a few particles of iron-pyrites. The sample, a single fragment, weighed ten ounces.

It contained neither gold nor silver.

14.—From No. 3 island, Point Hills islands, east coast of James bay.

A white translucent quartz, carrying very small quantities of iron-pyrites. The sample, a single fragment, weighed three ounces.

It contained neither gold nor silver.

15.—From No. 10 island, Paint Hills islands, east coast of James bay.

A white translucent quartz, stained with hydrated peroxide of iron. The sample, a single fragment, weighed eight ounces.

It contained neither gold nor silver.

16.—From No. 12 island, Paint Hills islands, east coast of James bay.

A white translucent quartz, carrying very small quantities of slightly weathered iron-pyrites. The sample, consisting of three fragments, weighed five ounces.

It contained neither gold nor silver.

17.—From the Pelton claim on No. 20 island, Paint Hills islands, east coast of James bay.

A massive iron-pyrites with which was associated small quantities of black hornblende. The sample, a single fragment, weighed three pounds. It was found to contain:

Gold..... none.
Silver..... ..... 0·058 of an ounce to the ton of 2,000 lbs.

18.—From No. 21 island, Paint Hills islands, east coast of James bay.

A massive iron-pyrites through which was distributed a small quantity of grayish-white, translucent quartz. The sample, consisting of several fragments, weighed two ounces.

It contained neither gold nor silver.

Province of Ontario.

19.—From mining location W. D. 129, fourteen miles west of Lake Wahnapitae, district of Nipissing.

A light bluish-white translucent quartz, in parts coated with hydrated-peroxide of iron. The sample, consisting of five fragments, weighed one pound eight ounces.

It contained neither gold nor silver.

20.—This, and the following specimen are from a point north of Rossport, district of Thunder bay.

A white granular, quartzite, carrying somewhat large quantities of iron-pyrites. The sample, a single fragment, weighed one pound six ounces.

It contained neither gold nor silver.

21.—A dark-gray quartzite, more or less coated with hydrated peroxide of iron, through which was distributed a few particles of iron-pyrites.

It contained neither gold nor silver.

North-west Territory.

22.—From a vein on Brown's mountain, Yellow Knife bay, Great Slave lake, Mackenzie district. This, and the following specimen were collected by Dr. R. Bell.

An association of white subtranslucent quartz with a little reddish-gray crystalline dolomite, carrying small quantities of stibnite. The sample, a single fragment, weighed four ounces.

It contained neither gold nor silver.

23.—From a large vein on the west side of East bay, Great Slave lake, Mackenzie district.

A white, cryptocrystalline quartz, stained and, in parts, coated with hydrated peroxide of iron. The sample, consisting of two fragments, weighed five ounces.

It contained neither gold nor silver.

24.—From Echo bay, Great Bear lake, Mackenzie district. Collected by Mr. J. M. Bell.

An association of white translucent quartz and white calcite, more or less coated with hydrated peroxide of iron and green carbonate of copper, holding small quantities of hematite and copper-pyrites. The sample, consisting of four fragments, weighed six ounces. Assays showed it to contain :

Gold..... .... none.
Silver..... 0·058 of an ounce to the ton of 2,000 lbs.

25.—From a quartz vein opposite claim 35, above Discovery claim, Bonanza creek, Yukon district. This, and the following seventeen specimens were collected by Mr. R. G. McConnell.

An association of a grayish-white talcose schist with some white translucent quartz and a very little felspar, carrying small quantities of zinc-blende, galena, and copper-pyrites. The sample, a single fragment, weighed four ounces. It was found to contain :

Gold..... .... distinct trace.
Silver..... 26·542 ounces to the ton of 2,000 lbs.

26.—From Indian river, a tributary of the Yukon, Yukon district.

A white subtranslucent quartz, slightly coated with hydrated peroxide of iron. The sample, a single fragment, weighed nine ounces.

It contained neither gold nor silver.

27.—From the Dome, Dominion Creek trail, Yukon district.

A white translucent quartz, stained and more or less, coated with hydrated peroxide of iron. The sample, a single fragment, weighed four ounces.

It contained neither gold nor silver.

28.—From near Fifteen-mile creek, Yukon river, Yukon district.

A mottled green (the colour being due to the presence of very fine scales of chromiferous mica) and yellowish-white dolomite. The sample, a single fragment, weighed one pound two ounces.

It contained neither gold nor silver.

29.—From Big Salmon river, Yukon district.

A white translucent quartz, stained and coated with hydrated peroxide of iron. The sample, a single fragment, weighed five ounces.

It contained neither gold nor silver

30.—From Stewart river, a tributary of the Yukon, Yukon district.

A grayish-white subtranslucent quartz, more or less stained and coated with hydrated peroxide of iron. The sample, a single fragment, weighed fifteen ounces. Assays gave:

Gold.....none.
Silver .....0·058 of an ounce to the ton of 2,000 lbs.

31.—From the Eldorado reef, Gay gulch, Yukon district.

A white translucent quartz, in parts stained and coated with hydrated peroxide of iron. The sample, a single fragment, weighed one pound seven ounces.

It contained neither gold nor silver.

32.—From Cone hill, Yukon river, Yukon district.

A grayish-white, in parts green (owing to the presence of minute scales of chromiferous mica), crystalline dolomite, here and there coated with hydrated peroxide of iron. The sample, a single fragment, weighed one pound two ounces. It was found to contain:

Gold.....none.
Silver.....0·117 of an ounce to the ton of 2,000 lbs.

33.—From opposite Cone hill, Yukon river, Yukon district.

A grayish-white, laminated quartzite, coated, in parts, with hydrated peroxide of iron. The sample, a single fragment, weighed ten ounces. It contained:

Gold.....none.
Silver.....0·058 of an ounce to the ton of 2,000 lbs.

34.—From the head of Adams creek, a tributary of Bonanza creek, Yukon district.

A white subtranslucent quartz, in parts coated with hydrated peroxide of iron and green carbonate of copper, carrying a very

little copper-pyrites. The sample, a single fragment, weighed seven ounces. Assays showed it to contain :

Gold.....none.
Silver..... ...12·717 ounces to the ton of 2,000 lbs.

35.—From Dion creek, Yukon river, near Dawson, Yukon district.

A moderately coarse quartz conglomerate, more or less coated with hydrated peroxide of iron. The sample, a single fragment, weighed nine ounces. It contained :

Gold.....none.
Silver.....0·117 of an ounce to the ton of 2,000 lbs.

36.—From east of Mooseskin mountain, on the north side of the Klondike river, not far from Dawson, Yukon district.

A white subtranslucent quartz, in part incrusted with white calcite and a little green carbonate of copper, carrying small quantities of copper-pyrites. The sample, a single fragment, weighed twelve ounces. It was found to contain :

Gold... .....none.
Silver.....0·292 of an ounce to the ton of 2,000 lbs.

37.—From Indian river, a tributary of the Yukon, Yukon district.

A white to dark-gray quartz conglomerate, stained and coated with hydrated peroxide of iron. The sample, a single fragment, weighed one pound one ounce.

It contained neither gold nor silver.

38.—Also from Indian river.

A white quartz conglomerate. The sample, a single fragment, weighed one pound two ounces.

It contained neither gold nor silver.

39.—From Stewart river, a tributary of the Yukon, Yukon district.

A grayish-white, schistose quartzite, in parts stained and coated with hydrated peroxide of iron, through which was disseminated a few particles of pyrrhotite. The sample, a single fragment, weighed one pound four ounces.

It contained neither gold nor silver.

40.—Also from the Stewart river.

An intimate association of quartz and dolomite, coated with hydrated peroxide of iron. The sample, a single fragment, weighed thirteen ounces.

It contained neither gold nor silver.

41.—From Mount Dominion, Yukon district.

A white subtranslucent quartz, in parts coated with hydrated peroxide of iron, carrying small quantities of iron-pyrites. The sample, a single fragment, weighed three ounces.

It contained neither gold nor silver.

42.—From the Yukon river, Yukon district.

A white cryptocrystalline quartz. stained with hydrated peroxide of iron. The sample, a single fragment, weighed ten ounces.

It contained neither gold nor silver.

43.—From the property of Mr. Thomas Brooks, of Stony beach, district of Assiniboia.

A finely crystalline galena in association with a little iron-pyrites and small quantities of a gangue composed of white translucent quartz and white calcite. The sample, a single fragment, weighed three ounces. It was found to contain :

Gold .....none.
Silver .....38·646 ounces to the ton of 2,000 lbs.

Province of British Columbia.

44.—From the Delhi claim, on the west side of Fry creek, Purcell range, west Kootenay district. Examined for Messrs. Turner & Keown.

An association of white cryptocrystalline quartz with a grayish-black chloritic-schist and a little brownish-black mica-schist, carrying small quantities of iron-pyrites, copper-pyrites and pyrrhotite. The sample, consisting of five fragments, weighed thirteen ounces. Assays showed it to contain :

Gold..... none.
Silver..... ...0·058 of an ounce to the ton of 2,000 lbs.

45.—From about eight miles south-west of Kaslo, West Kootenay district. Examined for Mr. Geo. T. Kane.

A highly ferruginous decomposed rock matter. Weight of sample, seventeen pounds.

It contained neither gold nor silver.

46.—From a mountain in the neighbourhood of Cluscus lakes, Cariboo district.

A grayish-white quartzo-felspathic rock, in parts stained with hydrated peroxide of iron, carrying small quantities of iron-pyrites. The sample, a single fragment, weighed five ounces.

It contained neither gold nor silver.

47.—From a vein near Manson creek, a stream flowing into Manson lake, Cassiar district.

A white subtranslucent quartz, carrying large quantities of a coarsely crystalline galena and a little iron-pyrites. The sample, consisting of three fragments, weighed five ounces. Assays gave :

Gold..... ...trace.
Silver.....32·812 ounces to the ton of 2,000 lbs.

48.—From granitic mass east of basic diorite on Nine-mile creek, Stikine river, Cassiar district.

A grayish-white to pale salmon coloured, moderately coarse crystalline, felspar. The sample, a single fragment, weighed seven ounces.

It contained neither gold nor silver.

49.—From the west slope of Dawson peaks, about five miles west of Teslin lake, Cassiar district.

A white, crystalline, triclinic felspar pitted with small patches of hydrated peroxide of iron, and holding a few disseminated particles of iron-pyrites. The sample, a single fragment, weighed six ounces.

It contained neither gold nor silver.

NATURAL WATERS.

1.—Water from a spring some two or three hundred yards back from the Tobique river, east side, and about a quarter of a mile above the mouth of the Wapskehegan, Victoria county, province of New Brunswick.

It contained a trifling quantity of white flocculent organic matter in suspension—this was removed by filtration. The filtered water was colourless, odourless and devoid of any marked taste. Reaction, neutral, both before and after concentration. Its specific gravity, at 15·5° C., was found to be 1001·82. Boiling produced a slight precipitate, consisting of carbonate of lime.

One thousand parts, by weight, of the filtered water, at 15·5° C., were found by Mr. F. G. Wait to contain:

Potassa	0·002
Soda	0·008
Lime	0·797
Magnesia	0·039
Sulphuric acid	1·069
Carbonic acid	0·175
Chlorine	0·002
Silica	0·006
Organic matter	trace.
	2·098

The foregoing acids and bases may reasonably be assumed to be present in the water in the following state of combination:

(The carbonate being calculated as monocarbonate, and all the salts estimated as anhydrous.)

Chloride of sodium	0·003
Sulphate of soda	0·016
" potassa	0·004
" lime	1·666
" magnesia	0·117
Carbonate of lime	0·198
Silica	0·006
Organic matter	trace.
	2·010
Carbonic acid, half-combined	0·087
" free	0·001
	2·098

Total dissolved solid matter, by direct experiment, dried at 180° C., = 2·086.

An imperial gallon of the water, at 15·5° C., would contain:

(The carbonate being calculated as anydrous bicarbonate, and the salts without their water of crystallization.)

	Grains.
Chloride of sodium	0·210
Sulphate of soda	1·122
" potassa	0·280
" lime	116·832
" magnesia	8·205
Bicarbonate of lime	19·986
Silica	0·421
Organic matter	trace.
	147·056
Carbonic acid, free	0·070
	147·126

Lithia, baryta, and strontia were sought for, but not detected.

2.—Water from a spring on the east bank of the Tobique river, about a mile and three-quarters, following the course of the river, above the mouth of the Wapskehegan, Victoria county, province of New Brunswick.

The sample received for examination, contained a small quantity of suspended matter of a light brown colour which, on removal by filtration, was found to consist of organic matter with a little hydrated peroxide of iron. The filtered water was of a faint brownish-yellow colour; was odourless; and devoid of any marked taste. It reacted neutral, both before and after concentration. The specific gravity, at 15·5° C., was found to be 1000·16. Boiling produced a very slight precipitate, consisting of carbonate of lime with a little carbonate of magnesia.

One thousand parts, by weight, of the filtered water, at 15·5° C., were found by Mr. F. G. Wait to contain:

Potassa	trace.
Soda	0·006
Lime	0·093
Magnesia	0·025
Ferrous oxide	trace.
Sulphuric acid	0·049
Carbonic acid	0·157
Chlorine	trace.
Silica	0·007
Organic matter	trace.
	0·337

The foregoing acids and bases may reasonably be assumed to be present in the water in the following state of combination :

(The carbonates being calculated as monocarbonates, and all the salts estimated as anhydrous.)

Chloride of sodium	trace.
Sulphate of soda	0·014
" potassa	trace.
" lime	0·070
Carbonate of lime	0·114
" magnesia	0·053
" iron	trace.
Silica	0·007
Organic matter	trace.
	0·258
Carbonic acid, half-combined	0·078
" free	0·001
	0·337

Total dissolved solid matter, by direct experiment, dried at 180° C., = 0·250.

An imperial gallon of the water, at 15·5° C., would contain :

(The carbonates being calculated as anhydrous bicarbonates, and the salts without their water of crystallization.)

	Grains.
Chloride of sodium	trace.
Sulphate of soda	0·980
" potassa	trace.
" lime	4·901
Bicarbonate of lime	11·482
" magnesia	5·671
" iron	trace.
Silica	0·490
Organic matter	trace.
	23·524
Carbonic acid, free	0·070
	23·594

Lithia, baryta and strontia were sought for, but not detected.

3.—Water of Salt brook, taken at its source, a stream flowing into the Tobique about two miles and a quarter, following the course of the river, above the mouth of the Wapskehegan, Victoria county, province of New Brunswick.

This water contained a trifling amount of light brown flocculent matter in suspension, which was removed by filtration. It con-

sisted of organic matter with a little hydrated peroxide of iron. The filtered water was clear and bright; had a pale brownish-yellow colour; was odourless, and devoid of any marked taste. Reaction, neutral; after evaporation to a small volume, however, decidedly alkaline. Its specific gravity, at 15·5° C., was found to be 1000·11. Boiling produced a slight precipitate, consisting of carbonate of lime with a little carbonate of magnesia.

One thousand parts, by weight, of the filtered water, at 15·5° C., were found by Mr. F. G. Wait to contain:

Potassa	0·002
Soda	0·005
Lime	0·064
Magnesia	0·013
Ferrous oxide	trace.
Sulphuric acid	0·002
Carbonic acid	0·134
Chlorine	0·003
Silica	0·005
Organic matter	trace.
	0·228
Less oxygen, equivalent to chlorine	0·001
	0·227

The foregoing acids and bases may reasonably be assumed to be present in the water in the following state of combination:

(The carbonates being calculated as monocarbonates, and all the salts estimated as anhydrous.)

Chloride of sodium	0·005
Sulphate of potassa	0·004
Carbonate of soda	0·003
" lime	0·114
" magnesia	0·027
" iron	trace.
Silica	0·005
Organic matter	trace.
	0·158
Carbonic acid, half-combined	0·065
" free	0·004
	0·227

Total dissolved solid matter, by direct experiment, dried at 180° C., = 0·152.

An imperial gallon of the water, at 15·5° C., would contain :

(The carbonates being calculated as anhydrous bicarbonates, and the salts without their water of crystallization.)

	Grains.
Chloride of sodium	0·350
Sulphate of potassa	0·280
Bicarbonate of soda	0·280
" lime	11·481
" magnesia	2·870
" iron	trace.
Silica	0·350
Organic matter	trace.
	15·611
Carbonic acid, free	0·280
	15·891

Lithia, baryta and strontia were sought for, but not detected.

4.—Water from a spring at Bay of Seven Islands, Saguenay county, province of Quebec. Examined for Mr. H. C. Thomson.

The sample sent for examination contained a trifling amount of suspended matter which, on removal by filtration, was found to consist of organic matter with a very little hydrated peroxide of iron. The filtered water had a faint brownish-yellow colour ; was odourless and tasteless. Reaction, neutral, both before and after concentration. Its specific gravity, at 15·5° C., was found to be 1000·10. Boiling produced a very slight precipitate, consisting of carbonates of lime and magnesia.

One thousand parts, by weight, of the filtered water, at 15·5° C., were found by Mr. F. G. Wait to contain :

Potassa	0·007
Soda	0·014
Lime	0.008
Magnesia	0·008
Ferrous oxide	trace.
Sulphuric acid	0·010
Carbonic acid	0·030
Chlorine	0·012
Silica	0·021
Organic matter	trace.
	0·110
Less oxygen, equivalent to chlorine	0·003
	0·107

The foregoing acids and bases may reasonably be assumed to be present in the water in the following state of combination :

(The carbonates being calculated as monocarbonates, and all the salts estimated as anhydrous).

Chloride of sodium	0·020
Sulphate of potassa	0·015
" soda	0·005
Carbonate of lime	0·014
" magnesia	0·017
" iron	trace.
Silica	0·021
Organic matter	trace.
	0·092
Carbonic acid, half-combined	0·015
	0·107

Total dissolved solid matter, by direct experiment, dried at 180° C.=0·080.

An imperial gallon of the water at 15·5° C. would contain :

(The carbonates being calculated as anhydrous bicarbonates, and the salts with their water of crystallisation.)

	Grains.
Chloride of sodium	1·40
Sulphate of potassa	1·05
" soda	0·35
Bicarbonate of lime	1·40
" magnesia	1·62
" iron	trace.
Silica	1·47
Organic matter	trace.
	7·29

5.—Water from a boring (E. Bergeron's) about two miles from the village of St. Grégoire, on concession Pointu, seigniory of Bécancour, Nicolet county, province of Quebec. The water, which was taken at a depth of six hundred feet, is from the Medina formation—Middle Silurian.

The sample received for examination, contained a small quantity of suspended matter which, on removal by filtration, was found to consist of argillaceous matter with some hydrated peroxide of iron and a little organic matter. The filtered water had a pale brownish-yellow colour; was odourless; and possessed a strongly saline, slightly bitter taste. Reaction, neutral—both before and after concentration. The specific gravity, at 15·5° C., was found to be 1,045·63.

Mr. F. G. Wait found one thousand parts, by weight, of the filtered water, at 15·5° C., to contain :

Potassa	0·144
Soda	25·676
Lithia	trace.
Lime	4·232
Magnesia	1·113
Alumina	0·035
Ferrous oxide	trace.
Manganous oxide	trace.
Sulphuric acid	0·181
Carbonic acid	0·070
Chlorine	36·537
Bromine	trace.
Iodine, very small quantity	undet.
Silica	0·022
Organic matter	trace.
	68·010
Chlorine required, in addition to that found, to satisfy bases	0·041
	68·051
Less oxygen, equivalent to chlorine	8·243
	59·808

The foregoing acids and bases may reasonably be assumed to be present in the water in the following state of combination :

(The carbonate being calculated as monocarbonate, and all the salts estimated as anhydrous.)

Chloride of potassium	0·227
" sodium	48·453
" lithium	trace.
" calcium	7·960
" magnesium	2·644
Bromide of sodium	trace.
Iodide of sodium, very small quantity	undet.
Sulphate of lime	0·308
Carbonate of lime	0·159
" iron	trace.
" manganese	trace.
Alumina	0·035
Silica	0·022
Organic matter	trace.
	59.808

Total dissolved solid matter, by direct experiment, dried at 180° C. = 59.912.

An imperial gallon of the water, at 15·5° C., would contain :

(The carbonate being calculated as monocarbonate, and all the salts estimated as anhydrous.)

	Grains.
Chloride of potassium	16·615
" sodium	3546·474
" lithium	trace.
" calcium	582·625
" magnesium	193·525
Bromide of sodium	trace.
Iodide of sodium, very small quantity	undet.
Sulphate of lime	22·544
Carbonate of lime	11·638
" iron	trace.
" manganese	trace.
Alumina	2·562
Silica	1·610
Organic matter	trace.
	4377·593

Baryta, strontia, and boric acid were sought for, and with negative results.

6.—Water from a hot spring on Sharp point, between Sydney inlet and Refuge cove, west coast of Vancouver island, province of British Columbia.

Temperature of the water at its source, where sample was collected, 124° F. Rate of flow, according to Mr. W. M. Brewer, M.E.—by whom it was collected, one hundred thousand gallons per day.

The sample received for examination, contained a very trifling amount of white, flocculent matter in suspension, which was removed by filtration. The filtered water was colourless, clear and bright. It was odourless and devoid of any marked taste. Reaction, neutral. Its specific gravity, at 15·5° C., was found to be 1000·5.

Agreeably with the results of an analysis by Mr. F. G. Wait, one thousand parts, by weight, of the filtered water, at 15·5° C., contained :

Potassa	0·002
Soda	0·185
Lime	0·028
Magnesia	0·002
Sulphuric acid	0·039
Chlorine	0·217
Silica	0·059
Organic matter	trace.
	0·532
Less oxygen, equivalent to chlorine	0.049
	0·483

Hypothetical combination :

Chloride of potassium	0·003
" sodium	0·348
" calcium	0·002
" magnesium	0·005
Sulphate of lime	0·066
Silica	0·059
Organic matter	trace.
	0·483

Total disolved solid matter, by direct experiment dried at 180° C. = 0·480.

An imperial gallon of the water, at 15·5° C., would contain :

	grains.
Chloride of potassium	0·210
" sodium	24·372
" calcium	0·140
" magnesium	0·350
Sulphate of lime	4·623
Silica	4·132
Organic matter	trace.
	33·827

Lithia, baryta, strontia, bromine, iodine, and carbonic acid, were sought for, and found to be absent.

7.—Water from a spring on the property of Mr. Hendricks, near Plumweseep station on the line of the Intercolonial railway, and three miles above Sussex, King's county, province of New Brunswick. Examined for Mr. John White.

The sample sent for examination, not more than six fluid ounces, contained a trifling quantity of brown flocculent matter in suspension. This was removed by filtration. The filtered water was colourless and bright ; devoid of odour ; and had a strong saline taste. Reaction, neutral—both before and after concentration. It contained 3356·5 grains of dissolved saline matter, dried at 180° C., per imperial gallon.

A qualitative analysis, by Mr. Wait, showed it to contain :

Soda	large quantity.
Lime	small quantity.
Magnesia	very small quantity.
Sulphuric acid	small quantity.
Carbonic acid	trace.
Chlorine	large quantity.
Silica	trace.

Boiling did not produce a perceptible precipitate.

8.—Water from a well on the farm of Narcisse Tetreau, St. Paul l'Ermite, L'Assomption county, province of Quebec.

The sample sent for examination contained a small quantity of brown, flocculent matter in suspension which, on removal by filtration, was found to consist of hydrated peroxide of iron with a very little organic matter. The filtered water was bright, colourless, and odourless. It had a faintly saline taste. Reaction, neutral—both before and after concentration. Its specific gravity, at 15·5° C., was found to be 1012·50. The total dissolved saline matter, dried at 180° C., amounted to 16·956 parts per 1000—equivalent to 1201·76 grains per imperial gallon.

Agreeably with the results of a qualitative analysis, conducted by Mr. Wait, it contained :

Potassa	trace.
Soda	large quantity.
Lithia	trace.
Ammonia	marked reaction.
Lime	rather small quantity.
Magnesia	rather small quantity.
Carbonic acid	somewhat large quantity.
Chlorine	large quantity.
Phosphoric acid	trace.
Nitrogen as nitrates	trace.
" nitrites	trace.
Silica	trace.
Organic matter	trace.

Baryta and strontia were sought for, but not detected.

Boiling produced a slight precipitate, consisting of carbonate of lime with a little carbonate of magnesia.

9.—Water from a spring at Ste. Rose, Laval county, province of Quebec.

This water at the time of its receipt, was faintly turbid ; after filtration, however, perfectly bright and colourless. It was odourless and devoid of any marked taste. Reaction, neutral, both before and after concentration. Its specific gravity, at 15·5° C., was found to be 1000·2. The total dissolved saline matter, dried at 180° C., amounted to 0·220 parts per 1000, equivalent to 15·4 grains per imperial gallon.

A qualitative analysis by Mr. Wait, indicated the presence of :

Soda	trace.
Lime	small quantity.
Magnesia	small quantity.
Ferrous oxide	trace.
Sulphuric acid	small quantity.
Carbonic acid	rather small quantity.
Chlorine	trace.
Silica	trace.
Organic matter	trace.

Boiling produced but a very slight precipitate, consisting of carbonate of lime with a little carbonate of magnesia.

10.—Water from a shallow well, sunk through sand to bed rock, on the east-half of the seventeenth lot of the tenth concession of the township of Ramsay, Lanark county, province of Ontario. Examined for Mr. J. K. Cole.

The sample examined contained a trifling quantity of reddish-brown sediment, which, on removal by filtration, was found to consist of organic matter with a little hydrated peroxide of iron. The filtered water, which was bright and clear, had a very faint brownish-yellow colour. It was odourless and devoid of any marked taste. Reaction, neutral—both before and after concentration. The specific gravity, at 15·5° C., was found to be 1000·5. It contained 0·256 parts of dissolved saline matter, dried at 180° C., in 1000 parts, by weight, of the water—equivalent to 17·92 grains per imperial gallon.

A qualitative analysis, by Mr. Wait, showed it to contain :

Soda	very small quantity.
Lime	small quantity.
Magnesia	very small quantity.
Sulphuric acid	very small quantity.
Carbonic acid	small quantity.
Chlorine	very small quantity.
Silica	trace.
Organic matter	trace.

Boiling produced a small precipitate, consisting of carbonate of lime with a little carbonate of magnesia.

11.—Water from a well on the fourth lot of the twelfth concession of the township of Dereham (i.e., on lot C., north of Oxford street and east of Harvey street, in the town of Tilsonburg), Oxford county, province of Ontario. Examined for Dr. S. Joy.

The sample sent for examination contained a very trifling quantity of brownish, flocculent, organic matter in suspension.

This was removed by filtration. The filtered water was bright, and, when viewed in a column two feet in length, of a pale greenish-yellow colour. It had a marked odour of sulphuretted hydrogen combined with a very faint one of petroleum. The taste corresponded more or less with the odour. Reaction, neutral. Its specific gravity, at 15·5° C., was found to be 1002·5. The total dissolved saline matter, dried at 180° C., in 1000 parts, by weight, of the filtered water, amounted to 1·98—equivalent to 139·16 grains per imperial gallon.

Mr. Wait made a qualitative analysis of this water and found it to contain :

Potassa	trace.
Soda	very small quantity.
Lime	rather small quantity.
Magnesia	rather small quantity.
Sulphuric acid	somewhat large quantity.
Carbonic acid	rather small quantity.
Chlorine	very small quantity.
Boric acid	trace.
Silica	trace.
Organic matter	trace.

Boiling produced a slight precipitate, consisting of carbonate of lime with some carbonate of magnesia.

12.—Water from a warm spring on the east shore of Atlin lake, ten miles south of Atlin city, Cassiar district, province of British Columbia. Collected by Mr. J. C. Gwillim.

It contained a very trifling quantity of white, flocculent, organic matter in suspension, which was removed by filtration. The filtered water was perfectly bright, and had a faint brownish-yellow colour. It was devoid of odour or any marked taste. Reaction, neutral—both before and after concentration. Its specific gravity, at 15·5° C., was found to be 1000·5. The total dissolved saline matter, dried at 180° C., amounted to 0·236 parts per 1000—equivalent to 16·53 grains per imperial gallon.

A qualitative analysis, by Mr. Wait, showed it to contain :—

Soda	very small quantity.
Lime	small quantity.
Magnesia	very small quantity.
Sulphuric acid	very small quantity.
Carbonic acid	small quantity.
Chlorine	very small quantity.
Silica	trace.
Organic matter	trace.

Boiling produced a slight precipitate, consisting of carbonate of lime with some carbonate of magnesia.

13.—So called 'soda water' from a spring near Discovery claim, three miles up McKee creek, east side of Atlin lake, Cassiar district, province of British Columbia. Collected by Mr. J. C. Gwillim. The sample of water received for examination contained a very trifling quantity of reddish-brown sedimentary matter which, on removal by filtration, was found to consist of hydrated peroxide of iron. The filtered water was clear, bright, colourless, and devoid of odour or any marked taste. Reaction, neutral, but when evaporated to a small volume, decidedly alkaline. Its specific gravity at 15·5°C., was found to be 1001·0. The total dissolved saline matter, dried at 180°C., amounted to 1·47 parts per 1000—equivalent to 103·00 grains per imperial gallon.

Agreeably with the results of a qualitative analysis, conducted by Mr. Wait, it contained:—

Soda	very small quantity.
Lime	rather small quantity.
Magnesia	rather small quantity.
Sulphuric acid	trace.
Carbonic acid	somewhat large quantity.
Chlorine	trace.
Silica	trace.
Organic matter	faint trace.

Boiling produced a rather small precipitate, consisting of carbonates of lime and magnesia.

MISCELLANEOUS EXAMINATIONS.

1.—Clay. From a deposit about six miles from Louisbourg and not far from the sea shore, Cape Breton county, province of Nova Scotia. Examined for Mr. W. Todd.

A light bluish-gray, non-calcareous, plastic, somewhat difficultly fusible clay, which when burnt assumes a light reddish-brown colour. It might advantageously be employed for the manufacture of ordinary building brick, drain tiles, and all kinds of common earthenware.

2.—Clay. Found respectively, overlying and underlying a seam of lignite on Rock creek, a tributary of the Klondike river, Yukon district, North-west Territory.

(*a.*) Overlying clay. Colour, light gray; is non-calcareous; contains but a very small proportion of gritty matter; is plastic;

when burnt, assumes a light brownish-yellow colour; is readily fusible at a somewhat elevated temperature. The burnt mass is more or less tender, hence this material would be but ill adapted for the manufacture of bricks.

(*b.*) Underlying clay. Colour dark gray; is non-calcareous; contains but very little gritty matter; is plastic; when burnt assumes a light reddish-brown colour; is somewhat readily fusible at an elevated temperature. The burnt mass is hard and firm. This clay might be employed for the manufacture of ordinary building brick.

3.—Clay. From Michel creek, East Kootenay district, province of British Columbia. Examined for Mr. W. Blakemore.

A dark brownish-gray, indurated clay; is non-calcareous; but feebly plastic; when burnt it assumes a light reddish-brown colour; is difficultly fusible. It does not afford a very strong brick.

4.—Clay. Under-clay from a seam of coal on Granite creek, a tributary of the Tulameen river, Yale district, province of British Columbia. Examined for Mr. Geo. de Wolf.

A faintly brownish light gray to yellowish-white, non-calcareous, highly plastic clay, which burns perfectly white, and is almost infusible. It could be used for the manufacture of pottery—including the finer varities of stoneware, is well suited for the manufacture of stove-linings, and would make a fairly refractory fire brick.

5.—Claystone. From about four miles north of Clinton, Lillooet district, province of British Columbia.

A light to dark brown, slightly calcareous, highly ferruginous, claystone. When reduced to a fine state of division, it forms with water a plastic mass, which when burnt assumes a dark reddish-brown colour. It is readily fusible, at a somewhat elevated temperature, to a black shining magnetic slag. This material might be employed for the manufacture of ordinary building brick.

6.—Coal. From Dunsinane, King's county, province of New Brunswick. Examined for Mr. John White.

(*a.*) Taken from a depth of one hundred and seventy feet. Thickness of seam, two feet. On incineration it left 19·56 per cent of a dark reddish-brown coloured ash.

(*b.*) Taken from a depth of one hundred and eighty-three feet. Thickness of seam, two feet two inches. On incineration it left 38·59 per cent of a light brownish-red coloured ash.

7.—Graphite, Disseminated. From Glendale, River Inhabitants, Inverness county, province of Nova Scotia. Examined for Mr. James MacIntosh.

The sample examined, contained 31·8 per cent of graphite. A specimen from the same locality, collected by Mr. Hugh Fletcher in 1879, was found by the writer to contain not more than 13·96 per cent of graphite, as recorded in Rep. Geol. Surv. Can., 1878–79, p. 2 H.

8.—Graphite, Disseminated. From the twenty-fifth lot of the fifth concession of the township of Blythfield, Renfrew county, province of Ontario. Examined for Mr. P. T. Barry.

(*a.*) Quartz holding some disseminated graphite. It contained 39·65 per cent of the latter.

(*b.*) Quartz with which was associated a little felspar, holding small quantities of graphite. The latter amounting to 5·37 per cent of the whole.

(*c.*) An association of felspar and quartz, through which was distributed a small quantity of graphite—not more than 4·32 per cent.

9.—Graphite. From the twenty-second lot of the second concession of the township of South Canonto, Frontenac county, province of Ontario. Examined for Mr. M. P. Kingston.

The sample sent for examination was found to contain 77·6 per cent of graphite.

10.—Graphite. From lot two of the sixth concession of the township of Bedford, Frontenac county, province of Ontario. Examined for Mr. J. Bawden.

The material sent for examination, consisted of graphite through which was distributed a gangue composed of a ferriferous calcite, a ferriferous dolomite, some quartz, and small quantities of felspar and actinolite. Mr. F. G. Wait found it to contain—graphite, 64·3; calcite and dolomite, 24·5; quartz and actinolite 11·2 = 100·0.

11.—Hematite. From Cape Rouge, Inverness county, province of Nova Scotia.

An association of specular iron with small quantities of limonite, which was in parts flecked with a little green carbonate of copper, and contained a few particles of copper-pyrites as likewise a small quantity of gangue—composed mainly of quartz with a little calcite. This sample contained 57·00 per cent of metallic iron.

12.—Magnetite. From the fourteenth lot of the eighth range of the township of Litchfield, Pontiac county, province of Quebec. Received from the Rev. W. Ferreri, of Vinton.

The material consisted of a slightly titaniferous magnetite, through which was distributed a little iron-pyrites and a somewhat large proportion of gangue—composed of chloritic schist, mica-schist and some quartz. This particular sample, contained 38·87 per cent of metallic iron.

13.—Magnetite. From the twelfth lot of the sixth range of the township of Sheen, Pontiac county, province of Quebec.

A compact, massive, slightly titaniferous, magnetite with which was associated a small quantity of gangue, composed, mainly of brown mica-schist with a little quartz. Determinations by Mr. F. G. Wait gave—metallic iron, 64·43; and insoluble matter, 2·68 per cent.

14.—Magnetite. From a creek entering the Tulameen at Otter Flat, Yale district, province of British Columbia. Examined for Mr. Geo. de Wolf.

A non-titaniferous magnetite, with some intermixed chlorite, quartz and mica. Mr. Wait found it to contain—metallic iron, 54·38; and insoluble matter, 15·39 per cent.

15.—Marl. From the west-half of the tenth lot of the first concession of the township of Stafford, Renfrew county, province of Ontario.

A light gray, earthy, marl, through which was distributed a few shells and some root-fibres. The insoluble mineral matter, which consisted principally of argillaceous matter with some minute grains of quartz, amounted to 6·25 per cent.

16.—Shale. From Hay Cove, Red Islands, Richmond county, province of Nova Scotia. Examined for Mr. M. L. MacNeil.

The material sent for examination consisted of a pale yellowish-greenish, non-calcareous shale, which when reduced to fine powder and moistened with water afforded a slightly plastic mass. This when burnt assumed a light reddish-brown colour. The burnt

mass was difficultly fusible at a high temperature. This material would be suitable for the manufacture of a fire-brick in which a very high degree of refractoriness was not called for.

17.—Shale, Ferruginous. A reddish-brown, ferruginous, argillaceous rock, having an uneven, slaty structure, from Monument Settlement, York county, province of New Brunswick, has been examined and found to contain—8·15 per cent of ferric oxide, equivalent to 5·71 per cent of metallic iron.

18.—Shale, Argillaceous. A bluish-ash coloured argillaceous shale from the lower part of the Pierre shales, Lethbridge, district of Alberta, North-west Territory. Collected by Dr. G. M. Dawson.

It is non-calcareous; plastic; when burnt assumes a reddish-brown colour; is fusible at a somewhat elevated temperature. This shale might advantageously be employed for the manufacture of ordinary building brick.

19.—Shale, Carbonaceous. From St. Liboire, township of Ramsay, Bagot county, province of Quebec.

A grayish-black, highly pyritous, calcareous, carbonaceous shale, containing 8·75 per cent of fixed carbon.

20.—Specular iron, Cupriferous. A very large deposit of crystalline massive specular iron, holding small quantities of intermixed green carbonate of copper, has been met with at the Pueblo claim on the White Horse copper-belt, west side of Lewes river, opposite White Horse and Miles canyon, Yukon district, North-west Territory. A specimen of this ore, collected by Mr. R. G. McConnell, has been examined by Mr. Johnston and found to contain:

Copper, metallic.....	2·98 per cent.
Insoluble matter, gangue.....	2·50 "

GEOLOGICAL SURVEY OF CANADA

SECTION OF

MINERAL STATISTICS AND MINES

ANNUAL REPORT

FOR

1899

ELFRIC DREW INGALL, M.E.

Associate of the Royal School of Mines, England, Mining Engineer to the Geological Survey of Canada.

ASSISTANTS

THEO. C. DENIS, B.A.Sc. J. MCLEISH, B.A.

OTTAWA

PRINTED BY S. E. DAWSON, PRINTER TO THE KING'S MOST EXCELLENT MAJESTY

1901

No. 718

To the Director
Geological Survey of Canada.

Sir,—Herewith permit me to hand you the detailed statistical report of the mineral industries of Canada for 1899. The preliminary summary statement for that year, which was completed on February 27, 1899, is of course replaced by the revised statement herein contained.

The work of the Section has consisted as in the past not only in the preparation of the annual report but in the collection of information and in making investigations of a great variety of matters pertaining to the economic mineral resources and mineral industries of the country, as well as in answering numerous inquirers on these matters. Besides this, a large amount of special work devolved upon the staff in connection with the preparation of the descriptive technical catalogue of the Dominion mineral exhibit at the Paris Exhibition.

Whilst the general technological work has fallen more particularly to the lot of Mr. Théo. Denis and myself, on Mr. J. McLeish has fallen the greater part of the work of preparation of the annual report, and thanks are due to these gentlemen as well as to Mrs. W. Sparks for their able performance of all the duties devolving upon them.

Thanks are also due to those, although too numerous to mention individually, who by answering our circulars or letters, provided much valuable material. Our acknowledgments are also due to the provincial mining bureaus of Nova Scotia, Quebec, Ontario and British Columbia, as well as to the Dominion Customs and Inland Revenue departments for aid received.

I am, sir,
Your obedient servant,

ELFRIC DREW INGALL.

Section of Mineral Statistics and Mines,
November 29, 1900.

NOTE.—*Unless otherwise stated, the bearings in this report are all referred to the true meridian.*

EXPLANATORY NOTES.

YEAR AND TON USED.

The year used throughout this report is the calendar year; except for the figures of imports, which refer to the fiscal year ending June 30th. The ton is that of 2,000 pounds, unless otherwise stated.

EXPORTS AND IMPORTS.

The figures given throughout the report referring to exports and imports are compiled from data obtained from the books of the Customs Department, and will occasionally show discrepancies, which however, there are no means of correcting.

The exports and imports under the heading of each province do not necessarily represent the production and consumption of the province, e.g., material produced in Ontario is often shipped from Montreal and entered there for export, so falling under the heading, Quebec.

N.E.S. = Not elsewhere specified.

VALUES ADOPTED.

The values of the metallic minerals produced, as per returns to this department, are calculated on the basis of their metallic contents at the average market price of the metal for the current year. Spot values have been adopted for the figures of production of the non-metallic minerals.

GENERAL NOTES.

As in the past, care is taken to avoid interference with private interests in the manner of publishing results, and all returns of production of individual mines are treated as confidential, unless otherwise arranged with those interested. The confidence of the mining community thus gained, has resulted in an increasingly general response to our circulars, although to complete our data personal application is still necessary in a small number of instances, and a yet more prompt response on the part of all applied to, will help still further towards an earlier publication of the material.

In view of criticisms of these statistics which have been made recently, and from time to time in the past, it may be well to take this opportunity to explain the working methods adopted, in order to prevent the misunderstandings which underlie such criticisms and suggestions, and to correct the impression thereby conveyed to the public that the reports are unreliable.

The figures given throughout the reports are based, as far as possible, upon returns obtained direct from the various operators, or from official data, and the totals have for some years been checked by comparison with railway shipments, exports, and all other available sources of information. It can be therefore fairly claimed, that they are as accurate as it is possible to make such figures.

After investigation of the subject we have, however, found that in the nature of things, export and railway figures can only be taken as approximately correct in most instances. In the case of the export figures, entries are made as a rule by those having no technical knowledge of mineral substances, and in the case of the railways, but few of the shipments are actually weighed, so that car-load lots, for instance, may differ considerably from the theoretical load of the car.

The lists of operators given throughout the report are not put forward as complete in every case, only those reporting their production being included. Producers finding their names omitted are invited to communicate with the office that they may be included in the next issue.

CORRECTIONS — ALTERATIONS.

Corrections and alterations have been made throughout this report wherever they seemed to be called for, according to more complete and reliable data available since previous issues.

The tabulated statement given in the folded sheet at the beginning of the report, represents a compilation of all the similar statements found in previous reports, re-modelled and further revised wherever possible.

INTRODUCTION.

The rapid growth of Canada's mineral industry which has been so marked during the past few years still continues, as will be seen by reference to the folder herewith appended. It will be seen that the increase of 1899 over 1898 amounts to nearly $11,000,000 or upwards of 28 per cent.

The growth of the industry as compared with that of our neighbours, the United States, is illustrated by the following figures. The per capita rates are of course based upon estimates of population for each year since the last census.

Year.	Canada.		United States.	
	Increase per cent in Grand Total.	Production per capita.	Increase per cent in Grand Total.	Production per capita.
	p.c.	$	p.c.	$
1899	28·13	9·33	39·86	12·84
1898	34·89	7·32	10·61	9·38
1897	26·90	5·52	1·33	8·66
1896	8·79	4·40	·21	8·73
1895		4·09		8·90
1890	64·00	3·50	38·97	9·89
1886		2·23		7·76

The relative importance of the different industries as contributors to the whole is as shown in the following table.

Proportionate Value of Different Mineral Products, 1899.

Products.	Contributing over 10 p.c.	Contributing between 10 and 1 p. c.	Contributing under 1 p.c.	Total.
1. Gold	42·88			
2. Coal and coke	21.45			
3. Copper		5·36		
4. Bricks (estimated)		4·43		
5. Nickel		4·17		
6. Silver		4·10		
7. Building stone (estimated)		3·03		
8. Petroleum		2·42		
9. Lead		1·97		
10. Lime (estimated)		1·61		
11. Cement		1·28		
12. Asbestus			·98	
13. Natural Gas			·78	
14. Gypsum			·52	
15. Salt			·51	
16. Iron ore			·48	
17. Sundry under 1 p.c.			4·03	
Total	64·33	28·37	7·30	100·00

CANADA'S MINERAL INDUSTRY.

On comparison with similar figures for 1898 some important changes are observable. Gold has increased its lead from about 36 per cent to about 43 per cent, thus being by far the largest item and with coal accounting for over 64 per cent of the whole. Silver has fallen away from third to sixth place, and lead from eighth to ninth, and other interesting changes will also be noted. A further analysis of the figures for 1899 gives the following interesting data regarding the relative importance of the different classes of mineral products. Thus, as stated, gold accounts for 42·88 per cent of which, a little over four-fifths came from placer workings, and almost all together those of the Yukon and Atlin districts. The other metals account for about 16 per cent, or a total metallic production of about 59 per cent. The combustible class is to be credited with 24·65 per cent, structural materials with 12·44 per cent, and all other non-metallic products with the remainder, about 4 per cent.

The location of the chief centres of mining activity in Canada will be apparent by reference to the tabulation below.

PRODUCTION BY PROVINCES, 1899.

Province.	Value of production.	Per cent.
	$	
Nova Scotia	6,996,041	14·1
New Brunswick	420,227	·9
Quebec	2,585,635	5·2
Ontario	9,819,557	19·8
Manitoba and North-west Territories	17,108,707	34·5
British Columbia	12,653,860	25·5
Total	49,584,027	100·0

It will be seen that 60 per cent of the mineral production of the country is due to the western section, Manitoba and the North-west Territories leading. This is of course due to the gold output of the Yukon, the other territories contributing less than $1,000,000, mostly coal, with the small gold production of the Saskatchewan River. British Columbia comes next as a very considerable factor, and Ontario, Nova Scotia, Quebec and New Brunswick follow in the order given.

Taking the separate industries of the Dominion, the proportional growth of each is illustrated by the subjoined figures:

Mineral Production of Canada, Calendar Years 1886 to 1899.

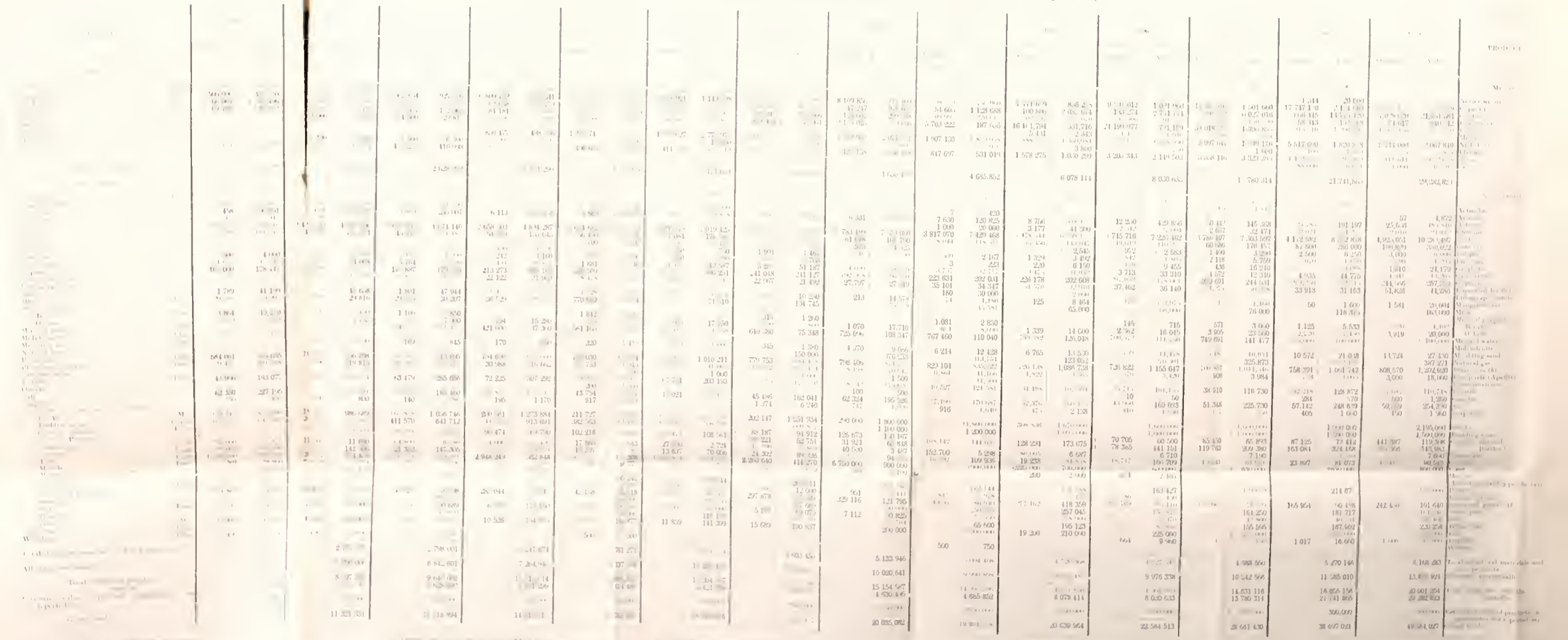


TABLE OF INCREASES AND DECREASES IN THE PRODUCTION OF THE VARIOUS MINERALS IN 1899, AS COMPARED WITH 1898.

PRODUCTS.	QUANTITY.		VALUE.	
	Increase.	Decrease.	Increase.	Decrease.
	p. c.	p. c.	p. c.	p. c.
Metallic—				
Copper		15·04	24·37	
Gold	54·34		54·34	
Iron ore	27·89		57·43	
Lead		31·50		19·00
Nickel	4·10		13·56	
Silver		23·37		21·64
Non-metallic—				
Asbestus and asbestic	7·36			1·09
Coal	18·03		25·06	
Coke	15·09		22·38	
Gypsum	11·54		10·67	
Natural gas			20·22	
Petroleum	6·62		13·21	
Salt	3·84		2·31	
Cement	58·57		59·29	

From the above it will be seen, that part of the increase in the grand total of the values of the mineral products of the country must be attributed to the world wide increase in prices favourably affecting Canada also, and which not only enhanced the effect of the considerable growth in the output in most of the industries, but even more than counterbalanced the falling off exhibited in some cases. The most marked increases in values are shown in copper, iron ore, nickel, coal, coke and petroleum, whilst serious depreciation of values occurred in lead and silver, although prices ruled higher.

The following tables give the exports and imports of mineral substances as gathered from the books of the Customs Department. The former, being for the calendar year, are in a degree comparable with the figures of production. It must however be borne in mind, as elsewhere pointed out in the report, that in many items the basis of valuation is very much lower than that adopted by this Section, especially in the case of metals and their ores.

CANADA'S MINERAL INDUSTRY.

Exports.

EXPORTS.

MINERALS AND MINERAL PRODUCTS OF CANADA DURING CALANDER YEAR 1899.

Products.	Value.	Products.	Value.
Antimony ore	$ 190	Manufactures of metals other than iron or steel	59,377
Asbestus, first class	70,807	Mica	153,002
" second class	183,338	Mineral pigments	5,408
" third class	219,003	Mineral waters	3,009
Bricks	1,351	Nickel	939,915
Cement	2,733	Oil refined	859
Chromite	19,876	Ores unspecified	85,645
Clay, manufactures of	220	Phosphate	3,575
Coal	3,864,443	Platinum	120
Coke	18,726	Plumbago, crude	19,326
Copper	1,199,908	" manufactures of	3,164
Felspar	5,126	Pyrites	34,084
Gold	6,437,029	Salt	2,773
Grindstones	21,579	Sand and gravel	101,640
" rough	1,709	Silver	1,623,905
Gypsum, crude	208,090.	Stone unwrought	101,931
" ground	8,123	" wrought	5,092
Iron and steel	975,377	Other articles	17,158
Iron ore	9,538		
Lead	466,950		
Lime	73,565	Total	$16,950,074
Manganese ore	2,410		

EXPORTS

DESTINATION OF PRODUCTS OF THE MINE, DURING THE FISCAL YEAR 1898–1899.

Destination.	Value.	Destination.	Value.
United States	$12,683,332	Spanish West Indies	$ 9,978
Newfoundland	180,938	Hong Kong	9,590
Hawaii	179,186	China	7,052
Great Britain	154,151	Russia	5,572
Belgium	40,755	Mexico	2,989
Australia	27,744	Holland	600
St. Pierre	20,062	Other countries	59
British West Indies	18,639		
Germany	15,074	Total	$13,368,150
British Guiana	12,429		

IMPORTS.

MINERALS AND MINERAL PRODUCTS, FOR FISCAL YEAR 1898–1899.

Products.	Value.	Products.	Value.
Alum and aluminous cake.	$ 41,387	Lead and mfrs. of	414,762
Aluminium	5,126	Lime	11,124
Antimony	16,861	Litharge	32,518
Arsenic	24,203	Lithographic stone	6,223
Asbestus and mfrs. of	32,607	Manganese, oxide of	5,539
Asphaltum	95,800	Marble and mfrs. of	101,879
Bismuth	422	Mercury	51,695
Blast furnace slag	7,553	Metallic alloys—	
Borax	65,664	Brass and mfrs. of	747,557
Bricks, tiles and sewer pipe, etc	128,242	Bronze, german silver, pewter, &c	77,391
Bricks, fire	126,995	Mineral and bituminous substances, N.E.S	23,103
Buhrstones	1,759	Mineral and metallic pigments, paints and colours	785,741
Building stone and granite	108,188	Mineral waters	54,891
Cement	480,414	Nickel	9,449
Chalk	10,461	Nitrate of soda, &c	346,063
Clays	88,517	Ores of metals, N.E.S	153,952
Coal	10,227,172	Paraffine wax	4,025
" tar and pitch	54,447	" candles	5,856
Coke	362,826	Petroleum and products of	763,303
Copper and mfrs. of	798,326	Phosphate (fertilizer)	5,669
Copperas	6,732	Phosphorus	478
Cryolite	2,120	Platinum	9,671
Earthenware	916,727	Precious stones	452,316
Emery	43,797	Pumice	5,973
Felspar, quartz, flint, &c	10,634	Salt	300,357
Fertilizers	78,396	Saltpetre	65,186
Fuller's earth	3,148	Sand and gravel	42,209
Graphite, crude	4,979	Slate	33,100
" mfrs. of	43,474	Spelter	29,687
Grindstones	27,476	Sulphate of copper	61,749
Gypsum, crude	692	Sulphur	265,799
" plaster of Paris, &c.	3,458	Tins and manufactures of	1,372,813
Iron and steel—		Whiting	34,310
Pigs, scrap, blooms, &c	899,094	Zinc and manufactures of	122,138
Rolled—bars, plates, &c., including chrome steel	4,773,935		
Ferro-silicon, ferro-manganese, &c	22,539	Total	$ 39,673,055
Manufactures of, machinery, hardware, &c	13,762,358		

ABRASIVE MATERIALS.

The abrasives produced in Canada continue to be confined to grindstones, wood pulp stones, scythe stones, etc., of Nova Scotia and New Brunswick. Some preparations are being made to open up commercially the deposits of corundum in Ontario, to which attention has lately been directed, but these have not yet reached a state of development to admit of a record of production.

The output of grindstones, etc, in 1899, amounted to 4,511 tons, valued at $43,265, a slight decrease from the figures of 1898, though quite up to the average of recent years.

ABRASIVE MATERIALS.

Grindstones.

The statistics of production since 1886 are given in Table 1, below

TABLE 1.

ABRASIVE MATERIALS.

ANNUAL PRODUCTION OF GRINDSTONES.

CALENDAR YEAR.	NOVA SCOTIA.		NEW BRUNSWICK.		TOTAL.		AVERAGE VALUE PER TON.
	Tons.	Value.	Tons.	Value.	Tons.	Value.	
1886	1,765	24,050	2,255	22,495	4,020	46,545	$11.58
1887	1,710	25,020	3,582	38,988	5,292	64,008	12.10
1888	1,971	20,400	3,793	30,729	5,764	51,129	8.87
1889	712	7,128	2,692	23,735	3,404	30,863	9.07
1890	850	8,536	4,034	33,804	4,884	42,340	8.67
1891	1,980	19,800	2,499	22,787	4,479	42,587	9.51
1892	2,462	27,610	2,821	23,577	5,283	51,187	9.69
1893	2,112	21,000	2,488	17,379	4,600	38,379	8.34
1894	2,128	16,000	1,629	16,717	3,757	32,717	8.71
1895	1,400	14,000	2,075	17,932	3,475	31,932	9.19
1896	1,450	14,500	2,263	18,810	3,713	33,310	8.97
1897	1,407	17,500	3,165	24,840	4,572	42,340	9.26
1898	1,422	12,350	3,513	32,425	4,935	44,775	9·07
1899	1,378	10,300	3,133	32,965	4,511	43,265	9·59

A large proportion of the production is exported, chiefly to the United States. Statistics of exports and imports are given in Tables 2, 3 and 4.

TABLE 2.

ABRASIVE MATERIALS.

EXPORTS OF GRINDSTONES.

CALENDAR YEAR.	Value.
1884	$28,186
1885	22,606
1886	24,185
1887	28,769
1888	28,176
1889	29,982
1890	18,564
1891	28,433
1892	23,567
1893	21,672
1894	12,579
1895	16,723
1896	19,139
1897	18,807
1898*	25,588
1899*	23,288

* Including stone for the manufacture of grindstones.

Table 3.

Abrasive Materials.

Exports of Grindstones by Provinces.

Province.	Calendar Year.				
	1895.	1896.	1897.	1898.	1899.
Ontario					$ 5
Quebec			$ 112		
Nova Scotia	$ 8,723	$ 12,145	12,094	$ 9,240	9,030
New Brunswick	8,000	6,994	6,601	16,348	14,253
Totals	$ 16,723	$ 19,139	$ 18,807	$ 25,588	23,288

Table 4.

Abrasive Materials.

Imports of Grindstones.

Fiscal Year.	Duty.	Tons.	Value.
1880		1,044	$11,714
1881		1,359	16,895
1882		2,098	30,654
1883		2,108	31,456
1884		2,074	30,471
1885		1,148	16,065
1886		964	12,803
1887		1,309	14,815
1888		1,721	18,263
1889		2,116	25 564
1890		1,567	20,569
1891		1,381	16,991
1892		1,484	19,761
1893		1,682	20,987
1894		1,918	24,426
1895		1,770	22,834
1896		1,862	26 561
1897		1,521	25,547
1898			22,217
1899 Grindstones not mounted and not less than 36 inches in diameter.	15 p.c.		22,273
1899 Grindstones N. E. S.	25 p c.		5,203
			27,476

Returns were received from but two operators in Nova Scotia, viz.

The Atlantic Stone Co., Lower Cove, Cumberland Co.

J. W. Sutherland, Quarry Island, Woodburne, Pictou Co.

From 45 to 50 men were employed for about half the year.

ABRASIVE MATERIALS.

Grindstones.

From New Brunswick some seven returns were received viz :—

From R. C. Ward, Rockport, Westmoreland Co.
H. C. Read, Sackville, " "
A. D. Richard, Dorchester, " "
W. B. Deacon, Shediac, " "
C. E. Fish, Newcastle, Northumberland Co.
J. B. Read, Stonehaven, Gloucester Co.
Lombard & Co, Clifton, " "

At the Rockport quarries the stones were roughly scabbled and shipped to Woodpoint a distance of about 10 miles, where they were finished in the lathe and sent to the United States.

Mr. H. C. Read worked the Woodpoint quarry near Sackville and the Coburg quarry near Bay Verte. Besides the finished grindstones he turned out a considerable quantity of rough building stone.

The Hon. A. D. Richard operated quarries at College Bridge Rockland and Fort Folly, all in the Parish of Dorchester, Westmoreland county.

The product was, besides building stone, grindstones for axes and pulp stones for grinding wood pulp.

W. B. Deacon took out and finished a number of stones from six to six and a half feet diameter and from nine to twelve inches thick, as samples, from a quarry at Buctouche, Kent county.

At the French Fort Quarry near New Castle on the Miramichi River Mr. C. E. Fish reports the demand for wood pulp stones increasing every year. A force of about 30 men was employed, the product being all shipped in a finished condition.

On the Bay of Chaleurs, Messrs Lombard & Co. worked their quarry as usual at Clifton, and Mr. J. B. Read had a considerable force employed at Stonehaven. This quarry lies under tide water of the bay, which is excluded by a clay dyke. A large part of the product is shipped to the United States to be used in the manufacture of edge tools and cutlery, while the remainder of the product consisting mostly of small stones is used in Canada for sharpening tools.

Abrasive Materials.

Buhrstones.

Table 5.

Abrasive Materials.

Imports of Buhrstones.

Fiscal Year.	Value.
1880	$12,049
1881	6,337
1882	15,143
1883	13,242
1884	5,365
1885	4,517
1886	4,062
1887	3,545
1888	4,753
1889	5,465
1890	2,506
1891	2,089
1892	1,464
1893	3,552
1894	3,029
1895	2,172
1896	2,049
1897	1,827
1898	1,813
*1899	1,759

*Buhrstones in blocks, rough or unmanufactured, not bound up or prepared for binding into mill-stones. Duty free.

Table 6.

Abrasive Materials.

Imports of Emery.

Emery.

Fiscal Year.	Emery. *a.*	Mfrs. of Emery. *b.*
1885	$ 5,066	$ 4,920
1886	11,877	5,832
1887	12,023	4,598
1888	15,674	4,001
1889	13,565	3,948
1890	16,922	5,313
1891	16,179	6,665
1892	17,782	6,492
1893	17,762	5,606
1894	14,433	2,223
1895	14,569	7,775
1896	16,287	11,913
1897	16,318	11,231
1898	17,661	15,478
1899	21,454	22,343

a Emery, in bulk, crushed or ground. Duty free.

b Emery wheels and manufactures of emery. Duty 25 p.c.

Abrasive Materials.

Pumice stone.

Table 7.

Abrasive Materials.

Imports of Pumice Stone.

Fiscal Year.	Value.
1885	$ 9,384
1886	2,777
1887	3,594
1888	2,890
1889	3,232
1890	3,003
1891	3,696
1892	3,282
1893	3,798
1894	4,160
1895	3,609
1896	3,721
1897	2,903
1898	3,829
*1899	5,973

* Pumice and pumice stone, ground or unground. Duty free.

Asbestus.

ASBESTUS.

Production.

Though complete returns were not received from asbestus producers we have been enabled to estimate from railway shipments, and other sources the missing figures, and the total production for 1899 is shown in Table 1 below. The product has been derived as usual from the mines in the 'Eastern Townships' of Quebec at Thetford, Black Lake and Danville, and from the Denholme mine north of Ottawa.

A small increase of 1,666 tons is shown in the production of asbestus, with a decrease in the value of $6,496, the average value per ton having been in 1898 $29.46 and in 1899 $26.34. This decrease in value however, should not be ascribed to any general fall in the price of asbestus but should rather be attributed to the continued increase, evidenced during the past few years, in the produc ion of the lower grade qualities of fibre, the lower value of which, pulls down the total average value.

ASBESTUS.

Production.

TABLE 1.

ASBESTUS.

PRODUCTION.—1896 TO 1899.

——	Tons.	Value.	Average Value per ton.
1896—Asbestus	10,892	$ 423,066	$ 38.84
Asbestic	1,358	6,790	5.00
	12,250	$ 429,856	$ 35.09
1897—Asbestus	13,202	$ 399,528	$ 30.26
Asbestic	17,240	45,840	2.66
	30,442	$ 445,368	$ 14.63
1898—Asbestus	16,124	$ 475,131	$ 29.46
Asbestic	7,661	16,066	2.10
	23,785	$ 491,197	$ 20.65
1899—Asbestus	17,790	$ 468,635	$ 26.34
Asbestic	7,746	17,214	2.22
	25,536	$ 485,849	19.03

The values of tbe different grades have averaged about $100 for firsts, $50 for seconds and from $10 to $15 for thirds.

The production of asbestic in 1899 amounted to 7,746 tons valued at $17,214 or an average value per ton of $2.22. These figures show but little change from those of the previous year.

In Table 1 the production of asbestus and asbestic, with the average value per ton of each, are shown for the years 1896 to 1899 inclusive, the production of asbestus previous to 1896 being shown in Table 2.

Asbestus.

oduct ce

Table 2.

Asbestus.

Production, &c.

Calendar Year.	Production.			Exports, Average value per ton.
	Tons (2,000 lbs.)	Value.	Average value per ton.	
		$	$ cts.	$ cts.
1880	380	24,700	65.00	Exports taken as production.
1881	540	35,100	65.00	
1882	810	52,650	65.00	
1883	955	68,750	71.98	
1884	1,141	75,097	65 80	
1885	2,440	142,441	58.37	
1886	3,458	206,251	59.64	
1887	4,619	226,976	49.14	63.25
1888	4,404	255,007	57.90	70.56
1889	6,113	426,554	69.77	64.44
1890	9,860	1,260,240	127.81	75.52
1891	9,279	999,878	107.75	70.07
1892	6,082	390,462	64.19	69.35
1893	6,331	310,156	49.02	57.24
1894	7,630	420,825	55.15	59.82
1895	8,756	368,175	42.05	56.66

The statistics of exports and imports are given in Tables 3 and 4.

Table 3.

Asbestus.

Exports.

Exports.

Calendar Year.	Tons.	Value.	Average value per ton.
1892	5,380	$373,103	69.35
1893	5,917	338,707	57.24
1894	7,987	477,837	59.82
1895	7,442	421,690	56.66
1896	11,842	567,967	47.96
1897	15,570	473,274	30.40
1898	15,346	494,012	32.19
1899 1st class	906	$ 70,807	78.15
1899 2nd "	3,935	183,338	46.60
1899 3rd "	13,042	219,003	16.79
Total, 1898	17,883	$473,148	26,46

Table 4.
Asbestus.
Imports.

Asbestus.

Imports.

Fiscal Year.	Value.
1885	$ 674
1886	6,831
1887	7,836
1888	8,793
1889	9,943
1890	13,250
1891	13,298
1892	14,090
1893	19,181
1894	20,021
1895	26,094
1896	23,900
1897	19,032
1898	26,389
*1899	32,607

*Asbestus, in any form other than crude, and all manufactures of. Duty 25 p.c.

CHROMITE.

Chromite.

The production of chromite in 1899 amounted to 2,010 tons, 11 tons less than for the previous year. The total value was $21,842, an average per ton of $10.86. The product is divisible into two grades, there being shipped 1,456 tons of the low grade ore valued at an average of $8.95 per ton, and 554 tons of high grade ore and concentrates valued at $15.90 per ton.

Table 1.
Chromite.
Annual Production.

Production

Calendar Year.	Tons, (2,000 lbs.)	Average Price per ton.	Value.
		$ c.	$
1886	* 60	15.75	945
1887	38	15.00	570
1888 to 1893	no output		
1894	1,000	20.00	20,000
1895	3,177	13.00	41,300
1896	2,342	11.53	27,004
1897	2,637	12.31	32,474
1898	*2,021	12.00	24,252
1899	2,010	10.86	21,842

* Railway shipments.

Chromite. The chromite is obtained entirely from the depcsits situated in the Eastern Townships of Quebec, and is sold chiefly in Pittsburg and Philadelphia. The total product to the end of 1899 has amounted to 13,285 tons, valued at $168,387. The figures of exports, as collected by the Customs Department, are shown below in Table 2 :—

Table 2.
Chromite.
Export Exports.

Calendar Year.	Tons.	Value.
1895	2,908	$ 42,236
1896	2,466	31,411
1897	2,106	26,254
1898	1,683	20,783
1899	1,509	19,876

Coal.

COAL.

Coal was formerly the most important of Canada's mineral production in point of value, and only yielded first place to gold in 1898 owing to the abnormal production of the precious metal, chiefly from the Yukon placers.

The production of coal, however, continues to grow with a steadiness which augurs well for the future of the industry, the value in 1899 amounted to over 20 per cent of the total mineral production, and the increase over the previous year both in point of quantity and percentage having been the greatest recorded.

The total production in 1899 amounted to 4,925,051 tons of 2,000 lbs. (4,397,367 tons of 2,240 lbs.) valued at $10,283,497, as compared with 4,172,582 tons of 2,000 lbs. valued at $8,222,878 in 1898.

The increase in 1899 over 1898 was 752,469 tons, or 18 per cent in quantity, and $2,060,619, or 25 per cent in value, the greater increase in the value being attributable to the enhanced price of coal in Nova Scotia.

The production by provinces in 1898 and 1899 was as follows : — Coal.

Table 1.

Coal.

Production by Provinces, 1898 and 1899. Production.

Province.	1898.		1899.	
	Tons.	Value.	Tons.	Value.
Nova Scotia	2,563,180	4,004,970	3,148,822	5,622,898
British Columbia	1 263,154	3,383,448	1,431,101	3,833,307
North-west Territories	340,088	825,220	334,600	811,500
New Brunswick	6 160	9,240	10,528	15,792
Total	4,172,582	$ 8,222,88	4,925,051	$10,283,497

As usual the greater part of the output comes from Nova Scotia, which contributed nearly 64 per cent of the total, British Columbia coming second with about 29 per cent. The remaining 7 per cent being produced in the North-west Territories and New Brunswick, The percentage of production to be credited to the several provinces at various periods since 1874 is as follows : —

Provinces.	1874.	1880.	1890.	1897.	1898.	1899.
	p. c.	p. c.	p. c.	p. c.	p. c.	p. c.
Nova Scotia	91	79	71	66	61·4	63·9
British Columbia	8	20	25	27	30·3	29·0
N. W. Territories and New Brunswick	.....	.....	4	7	8·3	7·1

It will be seen from the above figures that British Columbia has been steadily increasing its proportion of the total production, although in 1899 Nova Scotia shows the largest increase, viz. 22 per cent in quantity, as compared with 13 per cent for British Columbia.

Coal.

A comparison of the production of 1898 and 1899 by provinces is shown in Table 2.

Table 2.

Coal.

Production. Production. Comparison of 1898 and 1899.

Province.	Increase or Decrease.			
	Tons.	Per cent.	Value. $	Per cent.
Nova Scotia	*i* 585,642	*i* 22·85	*i* 1,617,928	*i* 40.40
British Columbia	*i* 167,947	*i* 13·29	*i* 449,859	*i* 13·29
North-west Territories	*d* 5,488	*d* 1·61	*d* 13,720	*d* 1·66
New Brunswick	*i* 4,368	*i* 70 91	*i* 6,552	*i* 70·91
Dominion	*i* 752,469	*i* 18·03	*i* 2,660,619	*i* 25·06

i Increase. *d* Decrease.

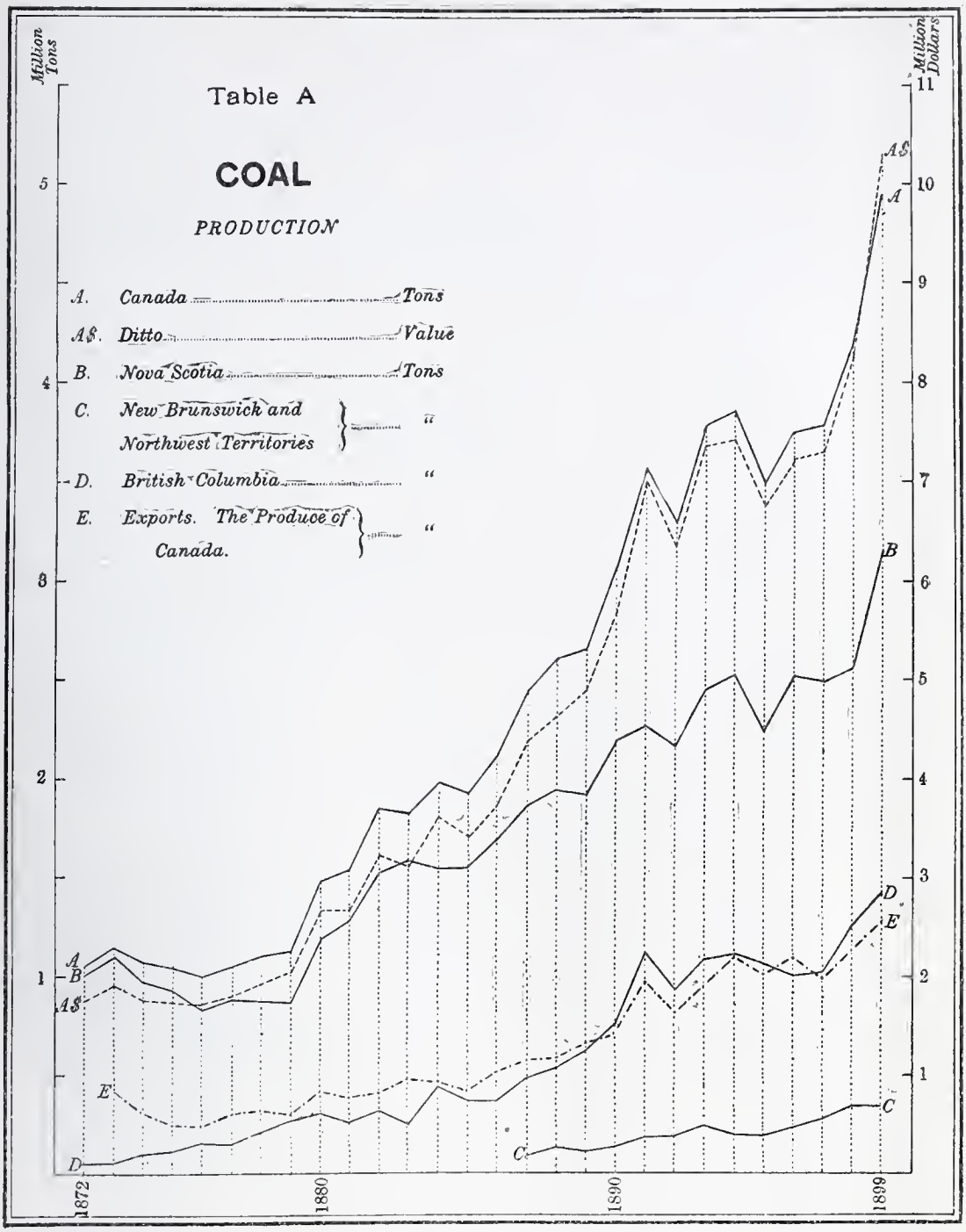
The statistics of production since 1886 showing the increases each year and the yearly average value per ton are given in Table 3, while graphic Table A illustrates at a glance the variations in the production both of the Dominion as a whole and of the several provinces.

Table 3.

Coal.

Annual Production showing the increase or decrease each year.

Calendar Year.	Tons.	Value.	Average Value per Ton.	Increase (*i*) or Decrease (*d*), in Tonnage.	Incr. (*i*) or Decr. (*d*) per cent.
1886	2,116,653	$3,739,840	$1.77	.....	.....
1887	2,429,330	4,388,206	1.81	*i* 312,677	*i* 14·8
1888	2,602,552	4,674,140	1.80	*i* 173,222	*i* 7·1
1889	2,658,303	4,894,287	1.84	*i* 55,751	*i* 2·1
1890	3,084,682	5,676,247	1.84	*i* 426,379	*i* 16·0
1891	3,577,749	7,019,425	1.96	*i* 493,067	*i* 16·0
1892	3,287,745	6,363,757	1.94	*d* 290,004	*d* 8·1
1893	3,783,499	7,359,080	1.95	*i* 495,754	*i* 15·1
1894	3,847,070	7,429,468	1.93	*i* 63,571	*i* 1·7
1895	3,478,344	6,739,153	1.94	*d* 368,726	*d* 9·6
1896	3,745,716	7,226,462	1.93	*i* 267,372	*i* 7·7
1897	3,786,107	7,303,597	1.93	*i* 40,391	*i* 1·1
1898	4,172,582	8,222,878	1.97	*i* 386,475	*i* 10·2
1899	4,925,051	10,283,497	2.09	*i* 752,469	*i* 18·0


Million Tons
Million Dollars
Table A
COAL
PRODUCTION
A. Canada ..... Tons
A$. Ditto ..... Value
B. Nova Scotia ..... Tons
C. New Brunswick and Northwest Territories ..... "
D. British Columbia ..... "
E. Exports. The Produce of Canada. ..... "
1872
1880
1890
1898

Coal.

Exports

A large proportion of the production of Nova Scotia and British Columbia, more especially the latter province, finds a market in adjacent portions of the United States, while for the supply of Ontario and portions of Quebec it is found more advantageous to import coal, both bituminous and anthracite, from the comparatively near fields of Pennsylvania.

The exports in 1899 amounted to about 26 per cent of the year's production. The following tables exhibit the statistics of exports and imports, the figures being obtained, as in past years, from the books and reports of the Customs Department.

Table 4.

Coal.

Exports.

Calendar Year.	Produce of Canada.	Not Produce.	Calendar Year.	Produce of Canada.	Not Produce.
	Tons.	Tons.		Tons.	Tons.
1873	420,683	5,403	1887	580,965	89,098
1874	310,988	12,859	1888	588,627	84,316
1875	250,348	14,026	1889	665,315	89,294
1876	248,638	4,995	1890	724,486	82,534
1877	301,317	4,829	1891	971,259	77,827
1878	327,959	5,468	1892	823,733	93,988
1879	306,648	8,468	1893	960,312	102,827
1880	432,188	14,217	1894	1,103,694	89,786
1881	395,382	14,245	1895	1,011,235	96,836
1882	412,682	37,576	1896	1,106,661	116,774
1883	486,811	44,388	1897	986,130	101,848
1884	474,405	62,665	1898	1,150,029	99,189
1885	427,937	71,003	1899	1,293,169	101,004
1886	520,703	78,443			

Coal.

Exports.

Table 5.

Coal.

Exports by Provinces.—The Produce of Canada.

Province.	Calendar Year.					
	1897.		1898.		1899.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
Ontario					305	$ 549
Quebec	610	$ 1,830	109	$ 218		
Nova Scotia	307,128	642,754	309,158	629,363	459,260	827,941
New Brunswick	8,208	25,816	593	1,433	2,341	6,683
P.E. Island			52	140		
N.W. Ter	39,843	72,188	26,274	39,418	49,454	81,901
Brit. Columbia	630,341	2,221,737	813,843	2,948,428	781,809	2,947,369
Total	986,130	$2,964,325	1,150,029	$3,619,000	1,293,169	$3,864,443

Table 6.

Coal.

Exports by Provinces.—Not the Produce of Canada.

Province.	Calendar Year					
	1897.		1898.		1899.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
Ontario	98,062	$ 178,044	98,424	$ 175,436	100,370	$ 162,309
Quebec	1,143	2,101	12	76	46	197
Nova Scotia	150	669	176	822	297	1,359
New Brunswick	2,493	6,891	267	627	291	777
Manitoba			310	1,148		
Total	101,848	$ 187,705	99,189	$ 178,109	101,004	$ 164,642

Coal.

Exports.

TABLE 7.

COAL.

EXPORTS.—NOVA SCOTIA AND BRITISH COLUMBIA.

Calendar Year.	Nova Scotia.		*British Columbia.	
	Tons.	Value.	Tons.	Value.
1874	252,124	$647,539	51,001	$ 278,180
1875	179,626	404,351	65,842	356,018
1876	126,520	263,543	116,910	627,754
1877	173,389	352,453	118,252	590,263
1878	154,114	293,795	165,734	698,870
1879	113,742	203,407	186,094	608,845
1880	199,552	344,148	219,878	775,008
1881	193,081	311,721	187,791	622,965
1882	216,954	390,121	179,552	628,437
1883	192,795	336,088	271,214	946,271
1884	222,709	430,330	245,478	901,440
1885	176,287	349,650	250,191	1,000,764
1886	240,459	441,693	274,466	960,649
1887	207,941	390,738	356,657	1,262,552
1888	165,863	330,115	405,071	1,605,650
1889	186,608	396,830	470,683	1,918,263
1890	202,387	426,070	508,882	1,977,191
1891	194,867	417,816	767,734	2,958,695
1892	181,547	407,980	599,716	2,317,734
1893	203,198	470,695	708,228	2,693,747
1894	310,277	633,398	770,439	2,855,216
1895	241,091	534,479	728,283	2,692,562
1896	380,149	787,270	679,799	2,507,752
1897	307,128	642,754	630,341	2,221,737
1898	309,158	629,363	813,843	2,948,428
1899	459,260	827,941	781,809	2,947,369

*See foot-note, table 18.

TABLE 8.

COAL.

Imports.

IMPORTS OF BITUMINOUS COAL.

Fiscal Year.	Tons.	Value.
1880	457,049	$1,220,761
1881	587,024	1,741,568
1882	636,374	1,992,081
1883	911,629	2,996,198
1884	1,118,615	3,613,470
1885	1,011,875	3,197,539
1886	930,949	2,591,554
1887	1,149,792	3,126,225
1888	1,231,234	3,451,661
1889	1,248,540	3,255,171
1890	1,409,282	3,528,959
1891	1,598,855	4,060,896
1892	1,615,220	4,099,221
1893	1,603,154	3,967,764
1894	1,359,509	3,315,094
1895	1,444,928	3,321,387
1896	1,538,489	3,299,025
1897	1,543,476	3,254,217
1898	1,684,024	3,179,595
*1899	2,171,358	3,691,946

*Duty, 53c. per ton.

Coal.

Imports.

TABLE 9.

COAL.

IMPORTS OF ANTHRACITE COAL.

Fiscal Year.	Tons.	Value.
1880	516,729	$1,509,960
1881	572,092	2,325,937
1882	638,273	2,666,356
1883	754,891	3,344,936
1884	868,000	3,831,283
1885	910,324	3,909,844
1886	995,425	4,028,050
1887	1,100,165	4,423,062
1888	†2,138,627	5,291,875
1889	1,291,705	5,199,481
1890	1,201,335	4,595,727
1891	1,399,067	5,224,452
1892	1,479,106	5,640,346
1893	1,500,550	6,355,285
1894	1,530,522	6,354,040
1895	1,404,342	5,350,627
1896	1,574,355	5,667,096
1897	1,457,295	5,695,168
1898	1,460,701	5,874,685
*1899	1,745,460	6,490,509

*Anthracite coal and anthracite coal dust. Free.

†In Table 9, Imports of Anthracite Coal, a very considerable increase will be noticed in 1888 over 1887, an increase of over ninety-four per cent, the falling off again in 1889 being quite as remarkable. The average values per ton for the three years 1887, 1888 and 1889, were $4.02, $2.47 and $4.03 respectively. Although a duty of fifty cents per ton on anthracite coal was removed May 13, 1887, it is hardly thought this would account for the changes indicated, and unless some error may possibly have crept into the Trade and Navigation Report, no explanation is available.

TABLE 10.

COAL.

IMPORTS OF COAL DUST.

Fiscal Year.	Tons.	Value.
1880	3,565	$ 8,877
1881	337	666
1882	471	900
1883	8,154	10,082
1884	12,782	14,600
1885	20,185	20,412
1886	36,230	36,996
1887	31,401	33,178
1888	28,808	34,730
1889	39,980	47,139
1890	53,104	29,818
1891	60,127	36,130
1892	82,091	39,840
1893	109,585	44,474
1894	117,573	49,510
1895	181,318	52,221
1896	210,386	53,742
1897	225,562	59,609
1898	229,445	45,556
*1899	276,547	44,717

*Duty, 20 p. c., not over 13c. per ton.

Coal.

Consumption.

Since we know the production, exports and imports of coal, we are enabled to arrive at a fair approximation of the consumption of coal in Canada, for though the figures of imports are given for the fiscal year, they may be taken to represent closely enough the importation during the calendar year.

The consumption for 1899 would be calculated as follows :—

	Tons.	Tons.
Production, Table 3	4,925,051	
Exports of coal the produce of Canada, Table 5	1,293,169	
Home consumption of Canadian coal		3,631,882
Imports of bituminous, anthracite and coal dust, Tables 8, 9 and 10	4,193,365	
Exports of coal not the produce of Canada, Table 6	101,004	
Home consumption of imported coal		4,092,361
Total consumption of coal in Canada, home and imported, 1899		7,724,243

In Table 11 will be found the results of similar calculations for each year since 1886. There is here shown the consumption of Canadian and imported coal, and the percentage of each as well as the total consumption per capita. The quantity of coal consumed in 1899 was greater than that used during the previous year by 1,426,709 tons, the increase being about 23 per cent.

Of the total amount consumed 53 per cent was imported and 47 per cent mined in Canada. The consumption per capita was 1.454 tons as compared with 1.200 tons in 1898, an increase of 21 per cent.

The relation between the total production in Canada as given in Table 3, and the total consumption, is interesting in that it exhibits the extent to which the country supplies its own requirements of this mineral. Thus in 1899 the production amounted to 63·7 per cent of the consumption while in 1898 the proportion was 66·1 per cent, and in 1897, 63·9 per cent. In 1890 it was 62·4 per cent, and in 1886, 60·8 per cent. The general tendency has therefore been towards an equilization of production and consumption.

Table 11. Coal.

Coal. Consumption.

Consumption of Coal in Canada.

Calendar Year.	Canadian.	Imported.	Total.	Percentage Canadian.	Percentage Imported.	Consumption per capita.
	Tons.	Tons.	Tons.			Tons.
1886.....	1,595,950	1,884,161	3,480,111	45·9	54·1	·758
1887.....	1,848,365	2,192,260	4,040,625	45·7	54·3	·871
1888.....	2,013,925	3,314,353	5,328,278	37·8	62·2	1·137
1889.....	1,992,988	2,490,931	4,483,919	44·4	55·6	·946
1890.....	2,360,196	2,581,187	4,941,383	47·8	52·2	1·031
1891.....	2,606,490	2,980,222	5,586,712	46·7	53·3	1·153
1892.....	2,464,012	3,082,429	5,546,441	44·4	55·6	1·133
1893.....	2,823,187	3,110,462	5,933,649	47·6	52·4	1·198
1894.....	2,743,376	2,917,818	5,661,194	48·5	51·5	1·130
1895.....	2,467,109	2,933,752	5,400,861	45·7	54·3	1·066
1896.....	2,639,055	3,206,456	5,845,511	45·1	54·9	1·140
1897.....	2,799,977	3,124,485	5,924,462	47·3	52·7	1·143
1898.....	3,022,553	3,274,981	6,297,534	48·0	52·0	1·200
1899.....	3,631,882	4,092,361	7,724,243	47·0	53·0	1·454

Nova Scotia.

Nova Scotia.

This is the largest coal producing province in the Dominion. In Table 12 are shown the statistics of output, sales, colliery consumption, etc., both in tons of 2,240 lbs. and in tons of 2,000 lbs.

The demand for coal in 1899 was quite brisk, and caused an increase in the price, making a general average for the year of $2 per ton. There was also a marked increase in production, amounting to nearly 23 per cent.

Table 12.
Coal.
Nova Scotia:—Output, Sales, Colliery Consumption and Production.

Calendar Year.	Output, Tons, 2,240 lbs.	Sales, Tons, 2,240 lbs.	Colliery Consumption, Tons, 2,240 lbs.	Production* Tons, 2,240 lbs.	Output, Tons, 2,000 lbs.	Sales, Tons, 2,000 lbs.	Colliery Consumption, Tons, 2,000 lbs.	Production* Tons, 2,000 lbs.	Price per Ton, 2,240 lbs.	Value of production.
1872	880,950	785,914	110,341	896,255	986,664	880,224	123,582	1,003,806	$1.75	$1,568,446
1873	1,051,467	881,106	108,398	989,504	1,177,643	986,839	121,406	1,108,245	1.75	1,731,632
1874	872,720	749,127	119,582	868,709	977,446	839,022	133,932	972,954	1.75	1,520,240
1875	781,165	706,795	124,110	830,905	874,905	791,610	139,003	930,613	1.75	1,454,084
1876	709,646	634,207	113,788	747,995	794,804	710,312	127,443	837,755	1.75	1,308,991
1877	757,496	687,065	98,841	785,906	848,396	769,513	110,702	880,215	1.75	1,375,339
1878	770,603	693,511	88,627	782,138	863,075	776,732	99,262	875,994	1.75	1,368,741
1879	788,271	688,624	84,787	773,411	882,863	771,259	94,961	866,220	1.75	1,353,469
1880	1,032,710	954,659	96,831	1,051,490	1,156,635	1,069,218	108,451	1,177,669	1.75	1,840,108
1881	1,124,270	1,035,014	107,888	1,142,902	1,259,183	1,159,216	120,834	1,280,050	1.75	2,000,079
1882	1,365,811	1,250,179	111,381	1,361,560	1,529,708	1,400,200	124,747	1,524,947	1.75	2,382,730
1883	1,422,553	1,297,523	111,949	1,409,472	1,593,259	1,453,226	125,383	1,578,609	1.75	2,466,576
1884	1,389,295	1,261,650	116,769	1,378,419	1,556,011	1,413,048	130,781	1,543,829	1.75	2,412,233
1885	1,352,205	1,254,510	127,624	1,382,134	1,514,470	1,405,051	142,939	1,547,990	1 75	2,418,735
1886	1,502,611	1,373,666	142,421	1,516,087	1,682,924	1,538,506	159,512	1,698,018	1.75	2,653,152
1887	1,670,830	1,519,684	139,777	1,659,461	1,871,330	1,702,046	156,550	1,858,596	1.75	2,904,057
1888	1,776,128	1,576,692	157,443	1,734,135	1,989,263	1,765,895	176,336	1,942,231	1.75	3,034,735
1889	1,756,279	1,555,107	158,131	1,713,238	1,967,032	1,741,720	177,107	1,918,827	1.75	2,998,167
1890	1,984,001	1,786,111	161,240	1,947,351	2,222,081	2,000,444	180,589	2,181,033	1.75	3,407,864
1891	2,044,784	1,849,945	174,983	2,024,928	2,290,158	2,071,938	195,981	2,267,919	1.75	3,543,624
1892	1,942,780	1,752,934	175,092	1,928,026	2,175,913	1,963,286	196,103	2,159,389	1.75	3,374,046
1893	2,223,042	1,977,543	205,425	2,182,968	2,489,807	2,214,848	230,076	2,444,924	1.75	3,820,194
1894	2,250,631	2,060,920	196,206	2,257,126	2,520,707	2,308,231	219,751	2,527,982	1.75	3,949,970
1895	1,999,756	1,793,098	193,639	1,986,737	2,239,727	2,008,270	216,875	2,225,145	1.75	3,476,790
1896	2,292,675	2,046,828	192,975	2,239,803	2,567,796	2,292,447	216,132	2,508,579	1.75	3,919,655
1897	2,340,031	2,044,672	181,716	2,226,388	2,620,835	2,290,032	203,522	2,493,554	1.75	3,896,179
1898	2,262,656	2,121,126	167,428	2,288,554	2,534,175	2,375,661	187,519	2,563,180	1.75	4,004,970
1899	2,865,443	2,633,989	177,460	2,811,449	3,209,296	2,950,067	198,755	3,148,822	2.00	5,622,898

* This Production is obtained by adding Sales and Colliery Consumption. For sales previous to 1872, see report of the Department of Mines, Nova Scotia, 1883, page 68.

The coal trade quarterly and by counties is exhibited in Table 13, and the output by collieries in Table 14.

Table 13.

Coal.

Nova Scotia :—Coal Trade by Counties.

Calendar Year.	Cumberland.		Pictou.		Cape Breton.		Other Counties.	
	Raised.	Sold.	Raised.	Sold.	Raised.	Sold.	Raised.	Sold.
	Tons, 2,000 lbs.	Tons, 2,000 lbs.	Tons, 2,000 lbs.	Tons, 2,000 lbs.	Tons, 2,000 lbs.	Tons, 2,000 lbs.	Tons, 2,000 lbs.	Tons, 2,000 lbs.
1st quarter.	127,874	116,079	116,156	95,684	402,600	119,853	1,092	372
2nd "	126,151	115,654	131,179	115,107	577,683	540,780	3,575	2,220
3rd "	99,867	95,423	136,741	130,320	604,952	784,753	5,592	5,301
4th "	136,771	128,362	160,788	145,751	578,145	554,332	130	76
Total, 1899	490,663	455,518	544,864	486,862	2,163,380	1,999,718	10,389	7,969
" 1898.....	479,067	430,980	457,092	415,170	1,577,794	1,512,173	20,220	17,337

Coal.

Nova Scotia.

Table 14.

Coal.

Nova Scotia:—Output by Collieries during the Calendar Year, 1899.

Colliery.	Tons, 2,000 lbs.	Colliery.	Tons, 2,000 lbs.
Cumberland County.		*Victoria County.*	
Joggins	74,550	New Campbelton	8,724
Scotia	567		
Springhill	415,546		
Pictou County.			
Acadia	301,540	*Cape Breton County.*	
Intercolonial	243,324		
Inverness County.		Dominion	1,864,101
		Sydney Mines	294,885
Broad-Cove	1,532	North Sydney	4,394
Mabou	3		
Pt. Hood	130	Total	3,209,296

The distribution of coal sold during the years 1898 and 1899 is shown in Table 15. A comparison of the two years will show, besides a general increase in the sales of coal, a greater proportion of sales in the United States. While in 1898 a little less than 3 per cent of the sales were made in the United States, in the following year nearly 11 per cent went to that country.

Table 15.

Coal.

Nova Scotia:—Distribution of Coal Sold.

Markets.	Calendar Years.			
	1898.		1899.	
	Tons, 2,000 lbs.	Per cent.	Tons, 2,000 lbs.	Per cent.
Nova Scotia, transported by land	384,976	16·2	390,494	13·2
" " sea	355,354	15·0	450,675	15·3
Total, Nova Scotia	740,330	31·2	841,169	28·5
New Brunswick	314,327	13·2	370,485	12·5
Prince Edward Island	71,177	3·0	76,622	2·6
Quebec	1,045,388	44·0	1,214,410	41·2
Newfoundland	92,473	3·9	120,163	4·1
West Indies	.....	.....	6,769	·2
United States	110,948	4·7	320,449	10·9
Other countries	1,018	.....	.....	.....
Total	2,375,661	100·0	2,950,067	100·0

NEW BRUNSWICK.

The statistics of coal production in New Brunswick are shown in Table 16, below. The quantities are small, and the production is for local uses only.

TABLE 16.
COAL.
NEW BRUNSWICK:—PRODUCTION.

Calendar Year.	Tons.	Value.	Value per ton.
1887	10,040	$ 23,607	$2.35
1888	5,730	11,050	1.93
1889	5,673	11,733	2.07
1890	7,110	13,850	1.95
1891	5,422	11,030	2.03
1892	6,768	9,375	1.39
1893	6,200	9,837	1.59
1894	6,469	10,264	1.59
1895	9,500	14,250	1.50
1896	7,500	11,250	1.56
1897	6,000	9,000	1.50
1898	6,160	9,240	1.50
1899	10,528	15,792	1.50

NORTH-WEST TERRITORIES.

The production of coal in the North-west Territories is shown in Table 17. There is but little change to record from the previous year. The chief centres of the industry, continue at the Galt mines at Lethbridge and the mines at Anthracite and Canmore, smaller amounts being mined in the vicinity of Edmonton and along the Souris river.

TABLE 17.
COAL.
NORTH-WEST TERRITORIES:—PRODUCTION.

Calendar Year.	Tons.	Value.	Value per ton.
1887	74,152	$ 157,577	$ 2.13
1888	115,124	183,354	1.59
1889	97,364	179,640	1.85
1890	128,953	198,498	1.54
1891	174,131	437,243	2.51
1892	184,370	469,930	2.55
1893	238,395	598,745	2.51
1894	199,991	488,980	2.45
1895	185,654	414,064	2.23
1896	225,868	606,891	2.69
1897	267,163	667,908	2.50
1898	340,088	825,220	2.43
1899	334,600	811,500	2.43

BRITISH COLUMBIA.

The statistics of production of coal in British Columbia are shown in Table 18, while the variations are also exhibited graphically in

Coal.

British Columbia.

Table A. An increase of 13 per cent is shown over the production of 1898. A little over 100,000 tons was taken out at the Crow's Nest Colliery, the balance coming from the Island of Vancouver. About one half the production of the province is exported, or more exactly 54.6 per cent in 1899.

TABLE 18.

COAL.

BRITISH COLUMBIA :—PRODUCTION.

Calendar Year.	Output Tons, 2,240 lbs.	Home Consumption, Tons, 2,240 lbs.	Sold for Export, Tons, 2,240 lbs. ‡	PRODUCTION.* Tons, 2,240 lbs.	PRODUCTION.* Tons, 2,000 lbs.	Price per ton, 2,240 lbs.	Value.
						$	$
1836-52..	10,000	From 1836 to 1873 inclusive, the output is taken as production.			11,200	4.00	40,000
1852-59..	25,398				28,446	4.00	101,592
1859¶...	1,989				2,228	4.00	7,956
1860.....	14,247				15,957	4.00	56,988
1861.....	13,774				15,427	4.00	55,096
1862.....	18,118				20,292	4.00	72,472
1863.....	21,345				23,906	4.00	85,380
1864.....	28,632				32,068	4.00	114,528
1865.....	32,819				36,757	4.00	131,276
1866.....	25,115				28,129	4.00	100,460
1867. ..	31,239				34,988	4.00	124,956
1868.....	44,005				49,286	4.00	176,020
1869.....	35,802				40,098	4.00	143,208
1870.....	29,843				33,424	4.00	119,372
1871-2-3.	148,459				166,274	4.00	593,836
1874.....	81,547	25,023	56,038	81,061	90,788	3.00	243,183
1875.....	110,145	31,252	66,392	97,644	109,361	3.00	292,932
1876.....	139,192	17,856	†122,329	140,185	157,007	3.00	420,555
1877.....	154,052	24,311	115,381	139,692	156,455	3.00	419,076
1878.. ..	170,846	26,166	164,682	190,848	213,750	3.00	572,544
1879.....	241,301	40,294	192,096	232,390	260,277	3.00	697,170
1880. ...	267,595	46,513	225,849	272,362	305,045	3.00	817 086
1881.....	228,357	40,191	189,323	229,514	257,056	3.00	688,542
1882.....	282,139	56,161	232,411	288,572	323,201	3.00	865,716
1883.....	213,299	64,786	149,567	214,353	240,075	3.00	643,059
1884. ...	394,070	87,388	306,478	393,866	441,130	3.00	1,181,598
1885.....	365,596	95,227	237,797	333,024	372,987	3.00	999,072
1886.....	326,636	85,987	249,205	335,192	375,415	3.00	1,005,576
1887....	413,360	99,216	334,839	434,055	486,142	3.00	1,302,165
1888.....	489,301	115,953	365,714	481,667	539,467	3.00	1,445,001
1889.....	579,830	124,574	443,675	568,249	636,439	3.00	1,704,747
1890.....	678,140	177,075	508,270	685,345	767,586	3.00	2,056,035
1891.....	1,029,097	202,697	806,479	1,009,176	1,130,277	3.00	3,027,528
1892	826,335	196,223	640,579	836,802	937,218	3.00	2,510,406
1893.....	978,294	207,851	768,917	976,768	1,093,980	3.00	2,930,304
1894.....	1,012,953	165,776	827,642	993,418	1,112,628	3.00	,980,254
1895.....	939,654	188,349	756,334	944,683	1,058,045	3.00	2,834,049
1896.....	894,882	261,984	634,238	896,222	1,003,769	3.00	2,688,666
1897.....	892,296	290,310	619,860	910,170	1,019,390	3.00	2,730,510
1898....	1,136,015	374,953	752,863	1,127,816	1,263,154	3.00	3,383,448
1899.....	1,306,324	526,058	751,711	1,277,769	1,431,101	3.00	3,833,307

* This production is obtained by adding "Home Consumption" and "Sold for Export." † 52,935 of this amount was reported as sales without the division into "Home Consumption" and "Sold for Export." ‡ The figures in the "Sold for Export" column do not agree as they should with those given in Table 7, the only explanation being that the data in the two cases are from different sources, and it has not been possible to find out the cause of the difference. ¶ Two months only.

The following table giving the source of California's coal supply in 1899 will illustrate the position which British Columbia coal occupies in this market. Coal. British Columbia.

Table showing source of California's coal supply for 1899 :—

	Tons of 2,000 lbs.
British Columbia	697,909
Australia	156,053
English and Welsh	104,454
Eastern Cumberland and Anthracite	43,625
Seattle, Washington	304,297
Tacoma, "	398,447
Mount Diable, Coos Bay and Tesla	212,248
Japan and Rocky Mountains (by rail)	31,797
Total	1,948,830

For detailed descriptions of the coal fields of Canada together with tables of analyses of Canadian coal, the reader is referred to the report of this Section for 1898.

COKE.

Coke.

The production of coke in 1899 was 100,820 tons valued at $350,022 or an average value per ton of $3.47. Compared with the previous year, this is an increase of 13,220 tons in quantity and $64,022 in value.

The annual production since 1886 is shown in Table 1 below :— Production.

TABLE 1.

COKE.

ANNUAL PRODUCTION.

Calendar Year.	Tons.	Value.	Value. per Ton.
1886	35,396	$101,940	$2·88
1887	40,428	135,951	3·36
1888	45,373	134,181	2·96
1889	54,539	155,043	2·84
1890	56,450	166,298	2·95
1891	57,084	175,592	3·08
1892	56,135	160,249	2·85
1893	61,078	161,790	2·65
1894	58,044	148,551	2·56
1895	53,356	143,047	2·68
1896	49,619	110,257	2·22
1897	60,686	176,457	2·91
1898	87,600	286,000	3·26
1899	100,820	350,022	3·47

The coke is manufactured in the provinces of Nova Scotia and British Columbia, and the production of these provinces for the past three years is shown in Table 2. Previous to 1896, there was but little coke made in British Columbia and the production was then practically all from the eastern province.

Production.

TABLE 2.
COKE.
PRODUCTION OF COKE BY PROVINCES.

Calendar Year.	Nova Scotia.		British Columbia.	
	Tons.	Value.	Tons.	Value.
		$		$
1897.	41,532	90,950	19,154	85,507
1898.	48,400	111,000	39,200	175,000
1899.	62,459	178,767	38,361	171,255

Although the eastern and western provinces are thus supplied by the local home product, Ontario and Quebec continue to import considerable quantities of coke from adjacent parts of the United States.

The imports of coke are shown in Tables 3 and 4.

Imports.

TABLE 3.
COKE.
IMPORTS OF OVEN COKE.

Fiscal Year.	Tons.	Value.
		$
1880.	3,837	19,353
1881.	5,492	26,123
1882.	8,157	36,670
1883.	8,943	38,588
1884.	11,207	44,518
1885.	11,564	41,391
1886.	11,858	39,756
1887.	15,110	56,222
1888.	25,487	102,334
1889.	29,557	91,902
1890.	36,564	133,344
1891.	38,533	177,605
1892.	43,499	194,429
1893.	41,821	156,277
1894.	42,864	176,996
1895.	43,235	149,434
1896.	61,612	203,826
1897.	83,330	267,540
1898.	135,060	347,040
1899.	141,284	362,826

Table 4. Coal.
Coke. Coke.
Imports of Oven Coke—Fiscal Years 1898 and 1899. Imports.

Province.	1898.		1899.	
	Tons.	Value.	Tons.	Value.
		$		$
New Brunswick	9	26	37	185
Quebec	10,226	35,001	9,459	33,249
Ontario	122,246	298,904	131,124	326,935
Manitoba	284	1,389	251	1,116
British Columbia	2,295	11,720	413	1,341
Totals	135,060	347,040	141,284	362,826

COPPER. Copper.

For the first time since 1894 the production of copper in Canada shows a decrease. The output in 1899 amounted to 15,078,475 lbs., being less than the output of the previous year by 2,668,661 lbs., a decrease of 15 per cent. In spite of this decrease, however, the total value of the copper produced in 1899 was greater than the value of the production of 1898, by over half a million dollars, owing to the great increase in the price of copper during the past year. The average price of refined copper in New York, in 1898, was 12·03 cents per pound, and in 1899 it was 17·61 cents, an increase of 5·58 cents per pound, or over 45 per cent.

Copper.

Production.

Table 1.

Copper.

Annual Production.*

Calendar Year.	Lbs.	Increase or Decrease.		Value.	Increase or Decrease.		Average Price per Pound.
		Lbs.	%		$	%	
				$			Cts.
1886.	3,505,000	... .	.....	385,550	.....	.....	11·00
1887.....	3,260,424	244,576	6·99	366,798	18,752	4·86	11·25
1888.	5,562,864	2,302,440	70·60	927,107	560,309	152·70	16·66
1889.....	6,809,752	1,246,888	22·40	936,341	9,234	0·99	13·75
1890.....	6,013,671	796,081	11·69	947,153	10,812	1·15	15·75
1891.	8,928,921	2,915,250	48·40	1,149,598	202,445	21·37	12·87
1892. .. .	7,087,275	1,841,646	20·62	818,580	331,018	28·79	11·55
1893.	8,109,856	1,022,381	14·40	871,809	53,229	6·50	10·75
1894..	7,708,789	401,067	4·94	736,960	134,849	15·46	9·56
1895.....	7,771,639	62,850	·81	836,228	99,268	13·47	10·76
1896... ..	9,393,012	1,621,373	20·86	1,021,960	185,732	22·21	10·88
1897.....	13,300,802	3,907,790	41·60	1,501,660	479,700	46·94	11·29
1898.....	17,747,136	4,446,334	33·43	2,134,980	633,320	42·17	12·03
1899.....	15,078,475	2,668,661	15·04	2,655,319	520,339	24·37	17·61

* The production is altogether represented by the copper contained in ore, matte, &c., produced and shipped, valued at the average market price for the year for fine copper in New York.

Note.—In the above table increases are shown underlined, and decreases in the ordinary way.

The various provinces contributed to the production in 1899 as follows:—British Columbia, 51 per cent; Ontario, 38 per cent and Quebec, but 11 per cent. In 1898, the proportions were:—British Columbia, 41 per cent; Ontario. 47 per cent and Quebec, 12 per cent. British Columbia has thus assumed the premier position in copper production, due not so much to the increase in that province, which amounted to only 6 per cent, as to the large decrease in Ontario, over 32 per cent. The variation in the production of the provinces and of the Dominion as a whole, is graphically set forth in Table B.

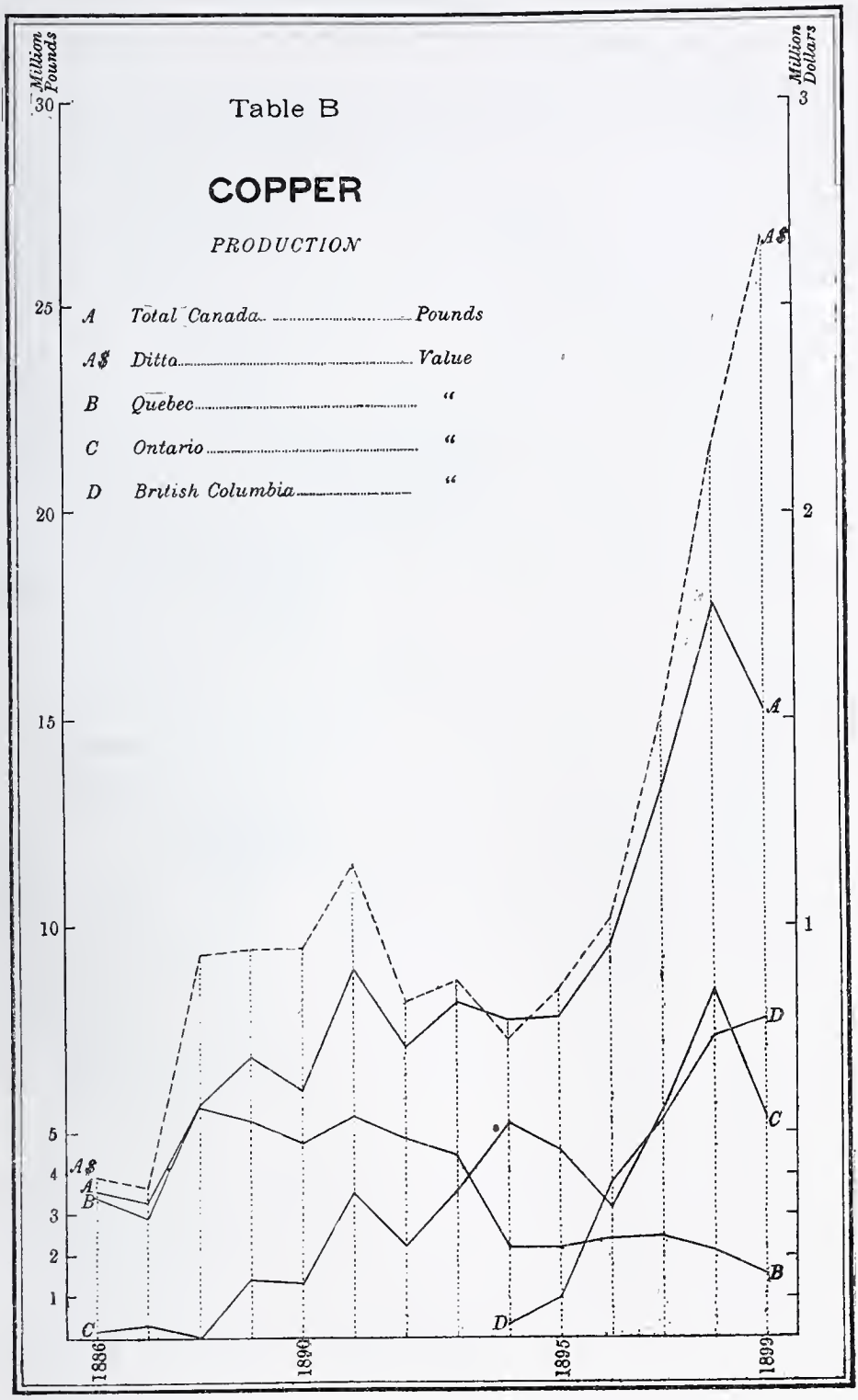

Million Pounds
Million Dollars
Table B
COPPER
PRODUCTION
A Total Canada ..... Pounds
A$ Ditto ..... Value
B Quebec ..... "
C Ontario ..... "
D British Columbia ..... "
30
25
20
15
10
5
4
3
2
1
3
2
1
A$
A
B
C
D
1886
1890
1895
1899

TABLE 2.

COPPER.

EXPORTS OF COPPER IN ORE, MATTE, ETC.

Calendar Year.	Nova Scotia.		Ontario.		Quebec.		British Columbia.		Total.	
	Lbs.	Value.	Lbs.	Value.	Lbs.	Value.	Lbs.	Value.	Lbs.	Value.
		$		$		$		$		$
1885						262,600				262,600
1886				16,404		232,855				249,259
1887				3,416		134,550				137,966
1888						257,260				257,260
1889						168,457				168,457
1890				2,219		396,278				398,497
1891				64,719		283,385				348,104
1892		100		79,141		198,391				277,632
1893			3,599,066	212,314	1,193,135	56,846			4,792,201	269,160
1894			242,804	25,029	285,909	12,065	1,097,576	54,883	1,625,389	91,917
1895			1,359,684	123,997	412,305	15,692	1,970,363	97,276	3,742,352	236,965
1896			49,000	1,100	290,845	12,368	5,122,207	267,602	5,462,052	281,070
1897			4,382,170	19,566	553,569	17,109	9,086,871	813,661	14,022,610	850,336
1898			3,800,000	6,071	340,389	34,054	7,431,992	800,118	11,572,381	840,243
1899		501	345,230	26,096			11,026,536	1,173,311	11,371,766	1,199,908

The exports of copper from Canada are given yearly in the Trade and Navigation Reports, and Table 2 is here given as usual showing the exports for the calendar year for the last 15 years. Copper. Exports.

As practically all the copper production is exported either in the form of matte or otherwise, these figures should agree with Table 1. This, however, they are far from doing.*

The imports of copper in pigs, etc., unmanufactured, are given in Table 3, and of manufactures of copper in Table 4.

The total imports in 1899 were valued at $798,320, as compared with $867,443 in 1898. The incease in importation of copper in pigs, or ingots, and scrap copper is most marked, being in 1899 $246,740, while for the previous year the value was only $80,914 and for 1897, $5,449. In contrast with this, however, the imports of manufactured copper were much less than in 1898 though still only exceeded in one other previous year. These tables do not include the copper entering into the manufacture of various classes of machinery, electrical and other, which is imported, and in that respect the tables are short in showing the actual quantities or values of copper entering the country.

TABLE 3.
COPPER.
IMPORTS OF PIGS, OLD, SCRAP, ETC. Imports.

Fiscal Year.	Lbs.	Value.	Fiscal Year.	Lbs.	Value.
		$			$
1880.....	31,900	2,130	1890.....	112,200	11,521
1881.....	9,800	1,157	1891.....	107,800	10,452
1882.....	20,200	1,984	1892.....	343,600	14,894
1883.....	124,500	20,273	1893.....	168,300	16,331
1884.....	40,200	3,180	1894.....	101,200	7,397
1885.....	28,600	2,016	1895.....	72,062	6,770
1886.....	82,000	6,969	1896.....	86,905	9,226
1887.....	40,100	2,507	1897.....	49,000	5,449
1888.....	32,300	2,322	1898.....	1,050,000	80,000
1889.....	32,300	3,288			
1899 { Copper, old and scrap or in blocks ..... Duty free				247,000	39,429
1899 { Copper in pigs or ingots ..... "				1,408,000	207,311
Total, 1899.....				1,655,000	246,740

*The discrepancies between the two tables result from differences in both quantities and values. The values in Table 1 are similar to those adopted throughout the report for metallic products, viz.: the final market value of the metal, while in the table of exports (Table 2) the values are apparently the spot values placed upon the metal at the point of shipment, although they will be seen to vary very considerably; as for instance, in 1897, ranging from less than half a cent per pound in Ontario to nearly nine cents per pound in British Columbia. The figures of quantity, however, also show large discrepancies, and for this we can offer no explanation, except to make the suggestion that the returns to some of the customs officers are not as correct as they might be.

Copper.

Imports.

Table 4.

Copper.

Imports of Manufactures.

Fiscal Year.	Value.
	$
1880	123,061
1881	159,163
1882	220,235
1883	247,141
1884	134,534
1885	181,469
1886	219,420
1887	325,365
1888	303,459
1889	402,216
1890	472,668
1891	563,522
1892	422,870
1893	458,715
1894	175,404
1895	251,615
1896	285,220
1897	264,587
1898	786,529

		Duty.	Pounds.	$
1899.	Copper, in bolts, bars and rods, in coils, or otherwise in lengths not less than 6 feet, unmanufactured	Free.	2,031,500	278,553
	Copper, in strips, sheets or plates, not planished or coated, &c	"	1,313,400	148,594
	Copper tubing in lengths not less than 6 feet, and not polished, bent or otherwise manufactured	"	136,796	29,292
	Copper rollers, for use in calico printing imported by calico printers for use in their own factories	"		11,310
	Copper and manufactures of :—			
	Nails, tacks, rivets and burrs or washers	30 p. c.		4,259
	Wire, plain, tinned or plated	15 "	280,648	45,144
	Wire cloth, &c	25 "		911
	All other manufactures of, N.O.P.	30 "		33,523
	Total			551,586

Nova Scotia.

Nova Scotia.

Although there is no production of copper to report from Nova Scotia, some considerable activity has been evidenced in the exploitation of the copper deposits of this province.

The following notes have been taken from the Report of the Department of Mines.

In Cape Breton county, during the summer, the Coxheath mines were unwatered, the machinery put in good order and the more important levels extended.

The Copper Crown Mining Company has been opening up some properties in Cumberland and Colchester counties and has been erecting a furnace at Pictou, where it is proposed to treat the ore. This Company has done more or less work at each of the following places: the Palmer mine, situated about four miles east of Winchester station, I.C.R., and on the west branch of the Wallace river: the King mine, about a mile east of Oxford town; the Riverside mine on the north bank of River Philip, about three miles east of Oxford; and the New Annan mine on the east branch of French river. At each of these places boilers and engines have been installed, and in some cases buildings erected for the accomodation of the workmen. COPPER.

QUEBEC. Quebec.

The output of this province for the year amounted to 1,632,560 pounds, the production having declined somewhat in recent years. The pyrites deposits of the county of Sherbrooke are as usual the chief source of supply, and the ore is mined principally for the sulphur it contains.

The Ascot mine, in the township of Ascot, which had been leased by its Canadian owners to Americans, was worked to a small extent, chiefly of an exploratory nature, and a small shipment made which was said to average about 11 per cent copper. The property has been again taken possession of by its Canadian owners, who have also done some exploratory work at the old Acton mine, the results of which are reported as exceedingly satisfactory.

Shipments were made from the Harvey Hill mine, in Leeds township, Megantic county, by Dr. James Reed, which averaged about 19 per cent. copper. Dr. Reed also did some exploring on his property in South Ham, from which about 20 tons of ore averaging 17 per cent copper, were shipped.

ONTARIO. Ontario.

The copper production of Ontario which is derived almost entirely from the copper-nickel deposits at Sudbury, amounted in 1899 to only 5,668,000 lbs. as compared with 8,373,560 lbs. in 1898—a decrease of 32 per cent. The quantity of ore treated in 1899 was greater than during the previous year, so that the decreased production of copper must be ascribed to a decrease in the copper contents of the ore mined.

Explorations were continued by the Parry Sound Copper Company at the McGowan mine, lot A, con. B, township of Foley, and the

Copper. Ontario.

Wilcox mine, lots 19, 20, 21 and 22, con. IV., township of Cowper, Parry Sound district. A small shipment of ore was made to Constable Hook, New Jersey.

The production of copper in Ontario as given by the Ontario Bureau of Mines is as follows in Table 5 with the exception of the final value which has been added to facilitate comparison with the other tables in the report.

Table 5.

Copper.

Ontario:—Production.

Year.	Pounds.	Spot Value.		Final Value.	
		Total.	Per lb.	Total.	Per lb.
		$	cts.	$	cts.
1892	3,872,000	232,135	6·00	447,216	11·55
1893	2,862,000	115,200	4·03	307,865	10·75
1894	5,496,000	195,750	3·56	525,418	9·56
1895	4,731,000	160,913	3·40	509,056	10·76
1896	3,736,000	130,660	3·50	406,477	10·88
1897	5,500,000	200,067	3·63	620,950	11·29
1898	8,373,560	268,080	3·20	1,007,339	12·03
1899	5,668,000	176,237	3·11	998,135	17·61

British Columbia.

British Columbia.

The statistics of production of copper in British Columbia for the past six years are shown in Table 6 below. The increase has been continuous from year to year, though only amounting to 6 per cent in 1899.

Table 6.

Copper.

British Columbia—Production.

Calendar Year.	Copper contained in ores, matte, &c.	Increase.		Final Value.
	Lbs.	Lbs.	%	
1894	324,680			$ 31,039
1895	952,840	628,160	193	102,526
1896	3,818,556	2,865,716	301	415,459
1897	5,325,180	1,506,624	39	601,213
1898	7,271,678	1,946,498	36	874,783
1899	7,722,591	450,913	6	1,359,948

The districts contributing most largely to the output in 1899 were, Trail creek, or Rossland, with nearly 74 per cent of the whole, and Nelson with about 18 per cent both in West Kootenay, the balance coming chiefly from the coast districts. COPPER.

In the Trail Creek mining division, in which it must be remembered the ores are mined more especially for their gold than their copper values, there was mined during the year 172,665 tons of ore, the copper contents of which amounted to 5,693,889 lbs., or an average of 1·65 per cent. About 94 per cent of the shipments of this division came from the Le Roi, War Eagle, and Centre Star mines alone.

In the Nelson division there was mined 58,302 tons of ore of which the copper contents amounted to 1,370,513 lbs., or an average percentage of 1·17.

The output of copper from the coast districts is yet small and is chiefly the product of mines in Texada island, on Mt. Sicker on the east coast, and near Alberni on the west coast of Vancouver Island.

GRAPHITE. GRAPHITE.

According to the returns received from various operators the production of graphite in 1899 was 1,310 tons valued at $24,179.

This is the largest production reported in any one year and greater than the value of the output of 1898 by $10,481.

The greater part of the product was crude graphite shipped from the Black Donald mine, Renfrew county, Ontario, by the Ontario Graphite Company of Ottawa. At Buckingham no mining was reported but the North American Graphite Company shipped some prepared graphite from stock in hand.

Some new work was undertaken by the Keystone Graphite Company of Scranton, Pennsylvania, on lot 10 A, range V. of Grenville township, Argenteuil county. According to Mr. H. P. Brumell, late manager, some shipments of fine lump ore were made to New Jersey and Chicago.

Graphite.

Production.

Table 1.
Graphite.
Annual Production.

Calendar Year.	Tons.	Value.
1886	500	$4,000
1887	300	2,400
1888	150	1,200
1889	242	3,160
1890	175	5,200
1891	260	1,560
1892	167	3,763
1893	nil.	nil.
1894*	3	223
1895	220	6,150
1896	139	9,455
1897	436	16,240
1898		13,698
1899	1,130	24,179

* Exports.

The exports and imports of graphite are shown in Tables 2 and 3 the total values of the exports in 1899 being $22,490 and of the imports $62,803.

Exports.

Table 2.
Graphite.
Exports.

Calendar Year.	N. Brunswick.		Ontario.		Quebec.		Nova Scotia.	
	Cwt.	Value	Cwt.	Value	Cwt.	Value	Cwt.	Value
		$		$		$		$
1886	8,142	3,586						
1887	6,294	3,017						
1888	2,700	1,080						
1889	660	422	22	116				
1890	400	160	329	1,369				
1891	464	72						
1892	1,224	449	15	60	4,590	3,443		
1893			12	38				
1894			69	223				
1895	1	8	1,087	4,825				
1896	270	106	2,285	7,418		351	160	1,605
1897			850	1,286		1,332	3,240	1,707
1898	1,356	635	10,445	10,878		1,575	9	10
1899 Crude			24,208	17,626			540	1,700
1899 Manufact'd.						3,164		
			24,208	17,626		3,164	540	1,700

TABLE 3. GRAPHITE.

GRAPHITE. Imports.

IMPORTS OF RAW AND MANUFACTURED GRAPHITE.

Fiscal Year.		Plumbago.	Manufactures of plumbago.	
			Black-lead.	Other Manufactures.
1880		$1,677	$18,055	$2,738
1881		2,479	26,544	1,202
1882		1,028	25,132	2,181
1883		3,147	21,151	2,141
1884		2,891	24,002	2,152
1885		3,729	24,487	2,805
1886		5,522	23,211	1,408
1887		4,020	25,766	2,830
1888		3,802	7,824	22,604
1889		3,546	11,852	21,789
1890		3,441	10,276	26,605
1891		7,217	8,292	26,201
1892		2,988	13,560	23,085
1893		3,293	16,595	23,051
1894		2,177	17,614	16,686
1895		2,586	13,922	21,988
1896		2,865	18,434	19,497
1897		1,406	17,863	20,674
1898		1,862	19,638	32,653
	Duty.			
1899 — Plumbago, not ground, etc.	10 p.c.	$4,979		
1899 — Black-lead	25 "		$ 21,334	
1899 — Plumbago, ground and manufactures of, N.E.S.	25 "			$22,140
1899 — Crucibles, clay and plumbago	Free			14,350
Total, 1899		$4,979	$21,334	$36,490

GYPSUM.

GYPSUM.

The production of gypsum, including plaster of Paris, and other manufactured products, in 1899 reached the highest value yet reported, amounting in all to 244,566 tons, valued at $257,329, or an average of $1.05 per ton. Compared with 1898 this is an increase of 11 per cent in quantity and 10 per cent in value, though only greater than the production in 1897 by 2 per cent in quantity and 5 per cent in value.

The output is, as usual, almost entirely from the eastern provinces of Nova Scotia and New Brunswick, a small amount being still mined in Ontario. In Nova Scotia a decrease in production is again shown, while in New Brunswick a considerable increase is evidenced.

GYPSUM.

The statistics of production since 1886, are shown in Tables 1 and 2.

Production.

The production for the past three years arranged according to class of product, viz: crude gypsum, calcined and land plaster and plaster of Paris and terra alba, is shown below.

Production 1897.	Tons.	Value.	Value per Ton.
		$	$ cts.
Crude gypsum	228,416	187,918	0·82
Calcined and land plaster	1,956	4,753	2·43
Plaster of Paris and terra alba	9,319	51,860	5·62
Total	239,691	244,531	1·02

Production 1898.	Tons.	Value.	Value per Ton.
		$	$ cts.
Crude gypsum	208,061	174,445	0·84
Calcined and land plaster	1,583	4,574	2·89
Plaster of Paris and terra alba	9,612	53,496	5.57
Total	219,256	232,515	1·06

Production 1899.	Tons.	Value.	Value per Ton.
		$	$ cts.
Crude gypsum	233,819	198,831	0·85
Calcined and land plaster	717	2,246	3·13
Plaster of Paris and terra alba	10,030	56,252	5·61
Total	244,566	257,329	1·05

TABLE 1.
GYPSUM.
ANNUAL PRODUCTION.

Calendar Year.	Tons.	Value.	Average price per ton.
1886	162,000	$178,742	$ 1.10
1887	154,008	157,277	1.02
1888	175,887	179,393	1.01
1889	213,273	205,108	0.96
1890	226,509	194,033	0.86
1891	203,605	206,251	1.01
1892	241,048	241,127	1.00
1893	192,568	196,150	1.02
1894	223,631	202,031	0.90
1895	226,178	202,608	0.89
1896	207,032	178,061	0.86
1897	239,691	244,531	1.02
1898	219,256	232,515	1.06
1899 Nova Scotia	126,754	102,055	0.81
1899 New Brunswick	116,792	151,296	1.30
1899 Ontario	1,020	3,978	3.90
Total, 1899	244,566	$257,329	$1.05

It will be seen that the greater part of the product, over 95 per cent., is crude gypsum. The plaster of Paris, with the exception of a small amount which is made in Ontario, is derived almost entirely from the Province of New Brunswick, and is manufactured by the Albert Manufacturing Company, at their Hillsborough Quarries, Albert county.

TABLE 2.
GYPSUM.
ANNUAL PRODUCTION BY PROVINCES.

CALENDAR YEAR.	NOVA SCOTIA.		NEW BRUNSWICK.		ONTARIO.		TOTAL.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
		$		$		$		$
1886							162,000	178,742
1887	116,346	116,346	29,102	29,216	8,560	11,715	154,008	157,277
1888	124,818	120,429	44,369	48,764	6,700	10,200	175,887	179,393
1889	165,025	142,850	40,866	49,130	7,382	13,128	213,273	205,108
1890	181.285	154,972	39,024	30,986	6,200	8,075	226,509	194,033
1891	161,934	153,955	36,011	33,996	5,660	18,300	203,605	206,251
1892	197,019	170,021	39,709	65,707	4,320	5,399	241,048	241,127
1893	152,754	144,111	36,916	41,846	2,898	10,193	192,568	196,150
1894	168,300	147,644	52,962	48,200	2,369	6,187	223,631	202,031
1895	156,809	133,929	66,949	63,839	2,420	4,840	226,178	202,608
1896	136,590	111,251	67,137	59,024	3,305	7,786	207,032	178,061
1897	155,572	121,754	82,658	118,116	1,461	4,661	239,691	244,531
1898	132,086	106,610	86,083	121,704	1,087	4,201	219,256	232,515
1899	126,754	102,055	116,792	151,296	1,020	3,978	244,566	257,329

Gypsum.

Exports.

The exports and imports of gypsum are shown in Tables 3, 4 and 5.

Table 3.

Gypsum.

Exports of Crude Gypsum.

Calendar Year.	Nova Scotia.		New Brunswick.		Ontario.		Total.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
1874	67,830	$ 68,164	.....	.....	.....	.....	67,830	$ 68,164
1875	86,065	86,193	5,420	$ 5,420	.....	.....	91,485	91,613
1876	87,720	87,590	4,925	6,616	120	$ 180	92,765	94,386
1877	106,950	93,867	5,030	5,030	.....	.....	111,980	98,897
1878	88,631	76,695	16,335	16,435	489	675	105,455	93,805
1879	95,623	71,353	8,791	8,791	579	720	104,993	80,864
1880	125,685	111,833	10,375	10,987	875	1,240	136,935	124,060
1881	110,303	100,284	10,310	15,025	657	1,040	121,270	116,349
1882	133,426	121,070	15,597	24,581	1,249	1,946	150,272	147,597
1883	145,448	132,834	20,242	35,557	462	837	166,152	169,228
1884	107,653	100,446	21,800	32,751	688	1,254	130,141	134,451
1885	81,887	77,898	15,140	27,730	525	787	97,552	106,415
1886	118,985	114,116	23,498	40,559	350	538	142,833	155,213
1887	112,557	106,910	19,942	39,295	225	337	132,724	146,542
1888	124,818	120,429	20	50	670	910	125,508	121,389
1889	146,204	142,850	31,495	50,862	483	692	178,182	194,404
1890	145,452	139,707	30,034	52,291	205	256	175,691	192,254
1891	143,770	140,438	27,536	41,350	5	7	171,311	181,795
1892	162,372	157,463	27,488	43,623	.....	.....	189,860	201,086
1893	132,131	122,556	30,061	36,706	.....	.....	162,192	159,262
1894	119,569	111,586	40,843	46,538	.....	.....	160,412	158,124
1895	133,369	125,651	56,117	67,593	.....	.....	189,486	193,244
1896	116,331	109,054	64,946	77,535	.....	.....	181,277	186,589
1897	122,984	116,665	66,222	80,485	.....	.....	189,206	197,150
1898	99,215	93,474	70,399	81,433	.....	.....	169,614	174,907
1899	104,795	99,984	96,831	198,094	*½	12	201,626	208,090

*Exported from British Columbia.

Table 4.

Gypsum.

Exports of Ground Gypsum.

Calendar Year.	Nova Scotia.	New Brunswick.	Ontario.	Total.
	$	$	$	$
1890	.....	.....	.....	105
1891	.....	.....	.....	588
1892	.....	.....	.....	20,255
1893	.....	.....	.....	22,132
1894	2,124	17,930	.....	20,054
1895	3,364	18,827	42	22,233
1896	1,270	19,246	751	21,267
1897	1,655	5,024	84	6,763
1898	1,548	4,900	.....	6,448
1899	205	7,898	20	8,123

TABLE 5. GYPSUM.

GYPSUM.

IMPORTS OF GYPSUM, ETC. Imports.

Fiscal Year.	Crude Gypsum.		Ground Gypsum.		Plaster of Paris.	
	Tons.	Value.	Pounds.	Value.	Pounds.	Value.
1880.....	1,854	$3,203	1,606,578	$ 5,948	667,676	$ 2,376
1881.....	1,731	3,442	1,544,714	4,676	574,006	2,864
1882.....	2,132	3,761	759,460	2,576	751,147	4,184
1883.....	1,384	3,001	1,017,905	2,579	1,448,650	7,867
1884.....	.....	3,416	687,432	1,936	782,920	5,226
1885.....	1,353	2,354	461,400	1,177	689,521	4,809
1886.....	1,870	2,429	224,119	675	820,273	5,463
1887.....	1,557	2,492	13,266	73	594,146	4,342
1888.....	1,236	2,193	106,068	558	942,338	6,662
1889.....	1,360	2,472	74,390	372	1,173,996	8,513
1890.....	1,050	1,928	434,400	2,136	693,435	6,004
1891.....	376	640	36,500	215	1,035,605	8,412
1892.....	626	1,182	310,250	2,149	1,166,200	5,595
1893.....	496	1,014	140,830	442	552,130	3,143
1894.....	.....	1,660	23,270	198	422,700	2,386
1895.....	603	960	20,700	88	259,200	1,619
1896.....	1,045	848	64,500	198	297,000	2,000
1897.....	.....	772	45,000	123	969,900	4,489
1898.....	1,147	1,742	35,700	293	329,600	2,025
1899.....	325	692	*33,900	338	496,300	3,120

*113 barrels.

Crude gypsum, duty free. Ground gypsum, duty 15%. Plaster of Paris, duty 12½c. per 100 lbs.

IRON.

IRON.

The production of iron ore in Canada is still comparatively small, amounting in 1899 to 74,617 tons valued at $240,542, though the increase over the production of 1898 was 16,274 tons and $87,754.

The output is used almost altogether in the blast furnaces, only small quantities being exported.

The ores mined in 1899 were those at Bridgeville, Nova Scotia, which were used by the Nova Scotia Steel Co., in conjunction with Newfoundland ores, and by the Mineral Products Co., the bog iron ore of Quebec, used in the manufacture of charcoal pig iron at the furnaces at Radnor and Drummondville, the ore found in eastern Ontario in Hastings county, etc., and used in the blast furnace at Hamilton, and some British Columbia ores from the Glen Iron mine near Kamloops and from Texada Island used as a flux by the smelters.

The production of pig iron in Canadian furnaces has increased rapidly during the past few years. This, however, can now only be partially claimed as a Canadian product, since in 1899 less than 40 per cent of the ore used in the furnaces was obtained from our own mines.

The annual production of ore, pig iron, etc., since 1886 is shown graphically in Table C below.

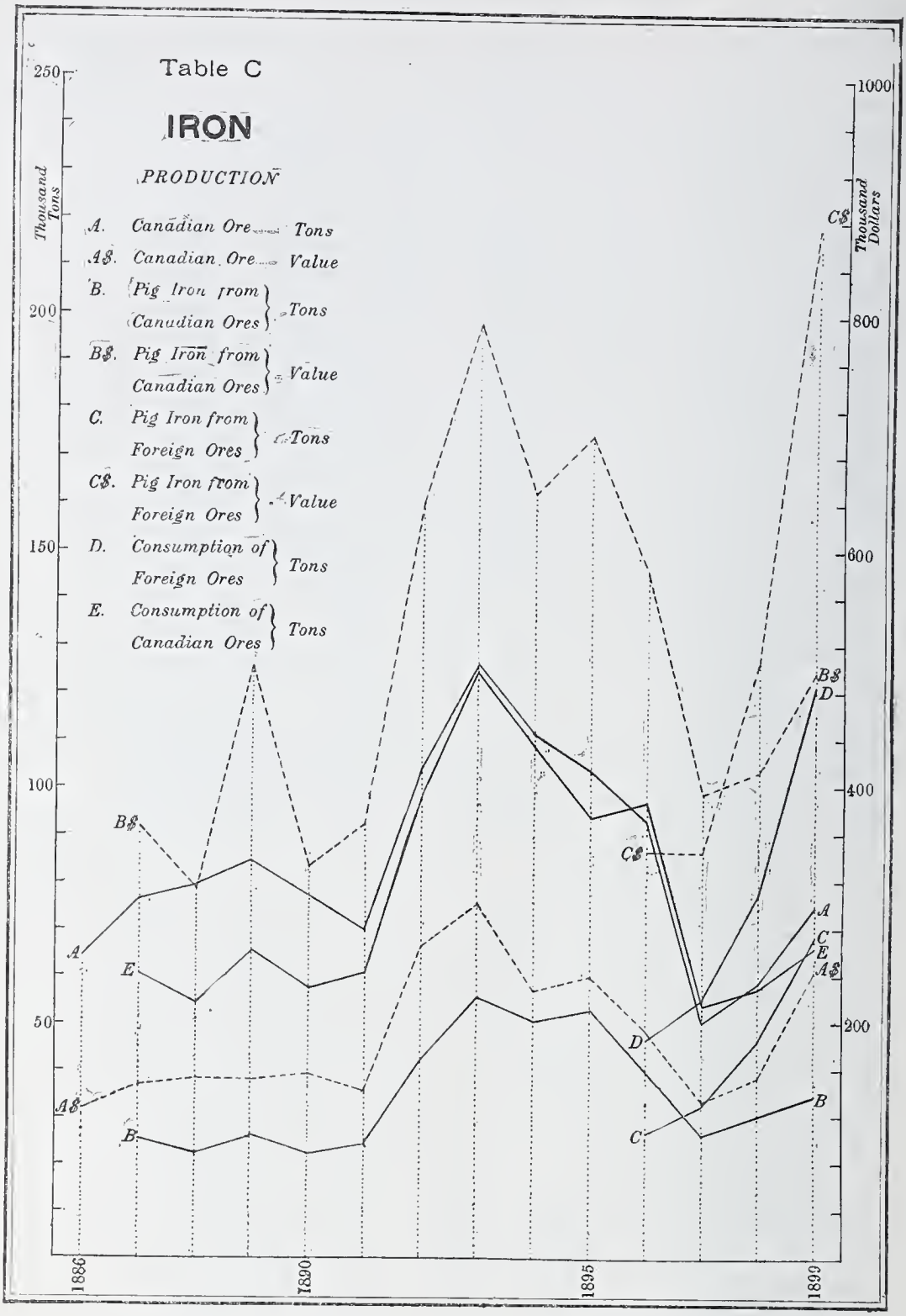


Table C
IRON
PRODUCTION
A. Canadian Ore — Tons
A$. Canadian Ore — Value
B. Pig Iron from Canadian Ores — Tons
B$. Pig Iron from Canadian Ores — Value
C. Pig Iron from Foreign Ores — Tons
C$. Pig Iron from Foreign Ores — Value
D. Consumption of Foreign Ores — Tons
E. Consumption of Canadian Ores — Tons
Thousand Tons
Thousand Dollars
250
200
150
100
50
1000
800
600
400
200
1886
1890
1895
1899

The production of ore by provinces in 1898 and 1899 was as follows:— Iron.

Production of ore.

Province.	1898.		1899.	
	Tons.	Value.	Tons.	Value.
		$		$
Nova Scotia	19,079	42,928	28,000	84,000
Quebec	17,873	46,033	19,420	50,161
Ontario	21,111	63,077	25,126	100,806
British Columbia	280	750	2,071	5,575
Total	58,343	152,788	74,617	240,542

The production of ore by provinces from 1886 to 1897 is given in Table 1, while in Table 2, the production in Nova Scotia since 1876 is shown.

Table 1.

Iron.

Production of Ore by Provinces.

Province.	1886.	1887.	1888.	1889.	1890.	1891.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Nova Scotia	44,388	43,532	42,611	54,161	49,206	53,649
Quebec	.....	13,404	10,710	14,533	22,305	14,380
Ontario	16,032	16,598	16,894	.....	5,000	.....
British Columbia	3,941	2,796	8,372	15,487	.....	950
Total	64,361	76,330	78,587	84,181	76,511	68,979

Province.	1892.	1893.	1894.	1895.	1896.	1897.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Nova Scotia	78,258	102,201	89,379	83,792	58,810	23,400
Quebec	22,690	22,076	19,492	17,783	17,630	22,436
Ontario	.....	.....	.....	.....	15,270	2,770
British Columbia	2,300	1,325	1,120	1,222	196	2,099
Total	103,248	125,602	109,991	102,797	91,906	50,705

Iron.

Production of ore.

The relative proportion of the output of ore by the different provinces in each of the last five years is shown in the following table :—

Table 1a.

Proportional Production of Ore by Provinces.

Province.	1895.	1896.	1897.	1898.	1899.
	%	%	%	%	%
Nova Scotia	81·51	63·99	46·15	32·70	37·52
Quebec	17·30	19·18	44·25	30·63	26·03
Ontario		16·62	5·46	36·19	33·67
British Columbia	1·19	0·21	4·14	·48	2·78
	100·00	100·00	100·00	100·00	100·00

Table 2.

Iron.

Nova Scotia.

Nova Scotia :—Annual Production of Ore.

Calendar Year.	Tons.
1876	15,274
1877	16,879
1878	36,600
1879	29,889
1880	51,193
1881	39,843
1882	42,135
1883	52,410
1884	54,885
1885	48,129
1886	44,388
1887	43,532
1888	42,611
1889	54,161
1890	49,206
1891	53,649
1892	78,258
1893	102,201
1894	89,379
1895	83,792
1896	58,810
1897	23,400
1898	19,079
1899	28,000

The exports of iron ore which are of small amount in recent years are given in Table 3.

Exports of ore.

TABLE 3.

IRON.

EXPORTS OF ORE.

Province.	CALENDAR YEAR.							
	1896.		1897.		1898.		1899.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
Ontario	*1,033	$ 1,911	..	..	143	$ 172	633	$ 2,834
Quebec	..	..	151	$ 286	39	106	1,761	4,507
Nova Scotia	..	..	..	..	..	..	..	..
British Columbia	..	..	252	525	..	..	1,751	2,197
Total	1,033	$1,911	403	$ 811	182	$ 278	4,145	$ 9,538

* Probably the product of the Province of Quebec, shipped via Ontario.

The production of pig iron in Canada in 1899 from Canadian and imported ores, according to returns furnished by furnace operators, was 102,940 tons valued at $1,377,306, or an average per ton of $13.38. These figures, however, do not include the output of the furnace of the Pictou Charcoal Iron Co. at Bridgeville, N.S., which was leased to the Mineral Products Co. for the manufacture of ferro-manganese, for which returns were not received. This furnace was in blast from about the 1st April to the 1st December, when an accident occurred preventing further operations. The total shipments according to an estimate received, were about 1,350 tons of spiegel, 450 tons of ferro-manganese and 900 tons of foundry pig. This would increase the year's output to over 105,000 tons.

The production of pig iron since 1887 is shown in Table 4. The increase in production in 1899 over 1898, excluding the output of the Mineral Products Company, was 25,925 tons, or 33 per cent in quantity and $464,911 or nearly 50 per cent in value. The total quantity of ore entering into the production was 187,034 tons, of which 66,384 tons or 35 per cent was mined in Canada, and 120,650 tons or 65 per cent imported. In 1898, 43 per cent of the ore mined was the product of Canadian mines and 57 per cent imported, while in 1897 and 1896 the percentages of Canadian ore used were respectively 49 per cent and 67·5 per cent. Previous to 1896 the iron was made entirely from Canadian ore.

Of the product in 1899, 19·5 per cent. or 20,104 tons was charcoal iron, while the balance, 82,839 tons was made with coke as fuel.

Iron.

Pig Iron Production.

To estimate the approximate amount of pig iron which should be credited to Canadian ore the output of each furnace has been divided in the proportion of the Canadian and foreign ores entering into its composition. On this basis the production of pig iron in the past four years has been as follows :—

Year.	From Canadian Ore.	From Imported Ore.
	Tons.	Tons.
1896	40,720	26,548
1897	26,200	31,807
1898	30,553	46,462
1899	34,244	68,699

These figures are, however, necessarily only approximate, since we are assuming the average iron contents of the various classes of ore used to be the same.

TABLE 4.
IRON.
PIG IRON PRODUCTION: CONSUMPTION OF ORE, FUEL, ETC.

CALENDAR YEAR.	IRON ORE CONSUMED.		FUEL CONSUMED.						FLUX CONSUMED.		PIG IRON MADE.		
			Charcoal.		Coke.		Coal.						
	Tons.	Value.	Bushels.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Value per ton.
		$		$		$		$		$		$	$
1887	60,434	130,808	940,400	48,593	30,248	89,123	3,333	5,877	17,171	17,500	24,827	366,192	14.75
1888	54,956	102,343	804,286	41,800	28,031	82,986	2,197	4,709	16,857	16,533	21,799	313,235	14.37
1889	65,670	126,064	755,800	41,568	33,289	94,791	3,044	6,525	22,122	21,909	25,921	499,872	19.28
1890	57,304	117,880	589,860	29,493	32,832	97,659	1,241	2,638	18,478	18,361	21,772	331,688	15.23
1891	60,933	130,955	441,812	22,091	30,626	98,402	2,170	2,868	11,377	11,546	23,891	368,901	15.44
1892	96,948	250,966	1,121,365	78,291	50,882	152,311	1,740	1,797	22,967	21,687	42,443	637,421	15.02
1893	124,053	296,979	1,302,720	90,976	58,711	163,849	6,621	13,539	27,797	27,519	55,947	790,283	14.13
1894	108,871	223,861	1,173,970	53,958	52,373	142,303	7,653	14,571	35,101	34,347	49,967	646,447	12.94
1895	93,208	218,336	789,561	31,582	48,540	139,475	3,089	5,396	31,585	29,922	52,454	696,440	13.28
1896 (a)	96,560	200,887	756,600	32,256	48,660	106,939	1,407	2,288	37,462	36,140	67,268	924,129	13.74
1896 (b)	46,300	100,205			33,990	109,253							
1897 (a)	53,658	131,705	1,031,800	43,230	35,800	71,600	.....	.....	31,273	30,258	58,007	738,701	12.73
1897 (b)	55,722	138,504			27,810	94,553							
1898 (a)	57,881	151,760	836,400	41,820	31,952	63,904	.....	.....	33,913	31,153	77,015	912,395	11.85
1898 (b)	77,107	213,165			50,407	158,783							
1899 (a)	66,384	216,322	1,928,025	87,858	44,844	134,532	.....	.....	51,826	44,286	102,940	1,377,306	13.38
1899 (b)	120,650	402,860			64,648	193,944							

(a) Canadian. (b) Foreign.

Iron.

Pig Iron Production.

There were altogether six furnaces in blast during the year, two in Nova Scotia, two in Quebec, and two in Ontario.

In Nova Scotia the Mineral Products Co., of Hillsborough, New Brunswick, as before mentioned, operated the furnace leased from the Pictou Charcoal Iron Co. Theirs was the first spiegeleisen and ferro-manganese produced in Canada. A mixture of charcoal and coke was used for fuel. The Nova Scotia Steel Co. operated continuously during the year with increased output. They continue to import a large proportion of their ore from Newfoundland. Only 40 per cent of the ore charged during the year was from Canadian mines. The furnace of the Londonnery Iron Company was not operated during the year.

The Dominion Iron and Steel Co., Ltd., in the fall of 1899 commenced the erection at Sydney of four blast furnaces. These will be the largest furnaces in Canada. They are to be 85 feet high, 17 feet in diameter at the bosh and will have an annual capacity of about 400,000 tons of iron. The company will bring in ore from the hæmatite deposits in Belle Island, Newfoundland. Operations have also been begun on 400 ovens of the Otto Hoffman type, for the manufacture of coke, in which the by-products will be saved, and the gas used in the blast furnaces. Preparation is also being made for the manufacture of steel.

The output of the furnaces at Radnor and Drummondville remained about the same. They are owned and operated respectively by the Canada Iron Furnace Co., and John McDougall & Co., of Montreal. They utilize the bog iron ores found in the counties of Champlain, Joliette and Vaudreuil and in Drummond and Nicolet, and employ charcoal as fuel.

In Ontario the manufacture of pig iron was commenced at the new furnace at Deseronto, by the Deseronto Iron Company, Ltd. Imported ore was charged, and charcoal employed for fuel. The Hamilton Blast Furnace Company increased their output. They use Pennsylvania coke as fuel, while about 72 per cent of the ore charged was obtained from the great iron deposits on the south shore of Lake Superior, the balance being derived largely from the deposits in eastern Ontario. Work was commenced on a new furnace at Midland, Ont., by the Canada Iron Furnace Company and it is expected to be ready to blow in in the latter part of 1900. The furnace will be 65 feet high and its bosh diameter 12 feet, and will have an annual capacity of about 30,000 tons of pig iron.

Table 5 shows the exports of iron and steel goods. In the exports of iron stoves and iron castings, small decreases are shown from the

figures of the previous year, but in all the other items substantial increases are indicated. The value of the scrap iron exported in 1899 was over ten times that sent out of the country in 1898. The exports of pig iron increased from a value of $32,645 to $149,190. Manufactured iron, machinery, hardware, etc., showed an increase of 47 per cent, and steel and manufactures of, an increase of about 70 per cent. IRON.

TABLE 5.

IRON.

EXPORTS OF IRON AND STEEL GOODS, THE PRODUCT OF CANADA.

CALENDAR YEAR 1899. Exports.

Province.	Scrap Iron.	Iron Stoves.	Iron Castings.	Pig Iron.	*Iron, all other, and Hardware.	Steel and manufactures of.	Totals.
	$	$	$	$	$	$	$
Ontario	24,732	455	62,342	40,924	260,051	33,161	421,665
Quebec	37,722	335	23,834	57,206	229,818	13,283	362,198
Nova Scotia	.....	2,021	1,658	51,060	63,793	40,330	158,862
New Brunswick	5,260	215	177	.....	3,135	2,070	10,857
Prince Edward Island	115	.....	.....	.....	277	.....	392
Manitoba	179	.....	.....	.....	908	278	1,365
North-west Territories	246	90	.....	.....	46	669	1,051
British Columbia	3,869	.....	1,550	.....	11,579	1,989	18,987
Total	72,123	3,116	89,561	149,190	569,607	91,780	975,377

*Machinery, N.E.S., sewing machines and hardware, N.E.S.

Iron.

The imports of iron in its cruder forms are shown in Tables 6, 7 and 8. These tables as well as 9a and 9b following are made up from the Trade and Navigation Reports, and are for the fiscal year.

TABLE 6.

IRON.

Imports.

IMPORTS OF IRON, PIG, SCRAP, ETC.

Fiscal Year.	Pig Iron.		Charcoal Pig Iron.		Old and Scrap Iron.		Wrought Scrap and Scrap Steel.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
		$		$		$		$
1880	(a) 23,159	371,956	.....	.....	928	14,042	.....	.....
1881	(a) 43,630	715,997	.....	.....	584	8,807	.....	.....
1882	56,594	811,221	6,837	211,791	1,327	20,406	.....	.....
1883	75,295	1,085,755	2,198	58,994	709	7,776	.....	.....
1884	49,291	653,708	2,893	66,602	3,136	44,223	.....	.....
1885	42,279	545,426	1,119	27,333	3,552	46,275	.....	.....
1886	42,463	528,483	3,185	60,086	10,151	158,100	.....	.....
1887	46,295	554,388	3,919	77,420	17,612	220,167	(b) 79	1,086
	Pig Iron, etc. (c)							
	Tons.	Value.						
		$						
1888	48,973	648,012	.....				23,293	297,496
1889	72,115	864,752	.....				26,794	335,090
1890	87,613	1,148,078	.....				47,846	678,574
1891	81,317	1,085,929	.....				43,967	652,842
1892	68,918	886,485	.....				32,627	433,695
	Pig Iron.		Charcoal Pig Iron.		Cast Scrap. Iron.			
	Tons.	Value.	Tons.	Value.	Tons.	Value.		
		$		$		$		
1893	56,849	682,209	5,944	84,358	729	9,317	45,459	574,809
1894	42,376	483,787	2,906	34,968	78	771	30,850	369,682
1895	(d) 31,637	341,259	2,780	31,171	643	4,347	23,390	244,388
1896	(d) 36,131	394,591	917	11,726	93	741	13,607	157,996
1897	(d) 25,766	291,788	2,936	35,373	238	1,362	7,903	93,541
1898	(d) 37,186	382,103	2,250	23,533	1,559	13,251	(e)48,903	534,577
1899	(d) 44,261	452,911	(f) 1,955	19,123	(f) 2,378	22,594	(e)28,352	301,268

(a) Comprises pig-iron of all kinds.

(b) From May 13 only.

(c) These figures appear in Customs reports under heading 'Iron in pigs, iron kentledge and cast scrap-iron.'

(d) Includes iron kentledge. Duty $2.50 per ton.

(e) Scrap iron and scrap steel, old, and fit only to be remanufactured, being part of, or recovered from, any vessel wrecked in waters subject to the jurisdiction of Canada. Duty free.

Iron or steel scrap, wrought, being waste or refuse, including punchings, cuttings and clippings of iron or steel plates or sheets, having been in actual use, crop ends of tin plate bars, blooms and rails, the same not having been in actual use. Duty $1 per ton.

(f) Duty $2.50 per ton.

Table 7.

Iron.

Imports of Ferro-manganese, etc.

Fiscal Year.	Tons.	Value.
*1887	123	$ 1,435
*1888	1,883	29,812
*1889	5,868	72,108
*1890	696	18,895
*1891	2,707	40,711
*1892	1,311	23,930
*1893	529	15,858
*1894	284	9,885
†1895	164	5,408
†1896	652	12,811
†1897	426	9,233
†1898	1,418	22,516
†1899 (Duty, 5 p.c.)	1,160	22,539

* These amounts include:—ferro-maganese, ferro-silicon, spiegel, steel bloom ends, and crop ends of steel rails, for the manufacture of iron or steel.

† Ferro-silicon, spiegeleisen and Ferro-manganese.

Table 8.

Iron.

Imports: Iron in Slabs, Blooms, Loops and Puddled Bars, etc.

Fiscal Year.	Cwt.	Value.
1880	195,572	$244,601
1881	111,666	111,374
1882	203,888	222,056
1883	258,639	269,818
1884	252,310	264,045
1885	312,329	287,734
1886	273,316	248,461
1887	522,853	421,598
1888	110,279	93,377
1889	80,383	67,181
1890	15,041	45,923
1891	41,567	38,931
1892	64,397	56,186
1893	65,269	58,533
1894	50,891	45,018
1895	78,639	67,321
1896	128,535	110,757
1897	56,560	48,954
1898	162,891	122,426
1899*	124,311	103,198

* Iron or steel ingots, blooms, slabs, billets, puddled bars and loops of other forms, N.O.P., less finished than iron or steel bars, but more advanced than pig iron, except castings. Duty, $2 per ton.

IRON.

Imports.

TABLE 9*a*.

IRON.

IMPORTS OF IRON AND STEEL GOODS.

Fiscal Year, 1899.		Duty.	Quantity.	Value.
				$
Bar iron or steel rolled, whether in coils, bundles, rods or bars, comprising rounds, ovals, squares and flats and rolled shapes, N.O.P.	Cwt.	$7 per ton.	325,946	448,569
Castings, iron or steel, in the rough, N.E.S.	$	25 %	.....	111,702
Canada plates, Russia iron, flat galvanized iron or steel sheets, terne plates and rolled sheets of iron or steel coated with zinc, spelter or other metal, of all widths or thicknesses, N.O.P.	Cwt.	5 "	426,950	954,605
Iron or steel bridges or parts thereof, iron or steel structural work, columns, shapes or sections drilled, punched, or in any further stage of manufacture than as rolled or cast, N.E.S	"	35 "	301,428	540,430
Malleable iron castings and iron or steel castings, N.E.S.	"	25 "	6,390	16,649
Mould boards, or shares or plough plates land sides and other plates for agricultural implements, cut to shape from rolled plates of steel but not moulded, punched, or otherwise manufactured	"	5 "	48,849	133,764
Iron or steel railway bars or rails of any form, punched or not punched, N.E.S., for railways, which term for the purposes of this item shall include all kinds of railways, street railways and tramways, even although the same are used for private purposes only, and even although they are not used or intended to be used in connection with the business of common carrying of goods or passengers	Tons.	30 "	4,823	86,614
Railway fish-plates and tie plates	"	$8 per ton.	5,821	131,498
Rolled iron or steel angles, tees, beams, channels, joists, girders, zees, stars or rolled shapes, or trough, bridge, building, or structural rolled sections, or shapes not punched, drilled or further manufactured than rolled, N.E.S., and flat eye bar blanks not punched or drilled	Cwt.	10 %	241,407	251,205
Rolled iron or steel hoop, band, scroll or strip, 8 inches or less in width, No. 18 gauge and thicker, N.E.S.	"	$7 per ton.	31,497	43,300
Rolled iron or steel hoop, band, scroll or strip, thinner than No. 18 gauge, N.E.S.	"	5 %	154,639	86,518
Rolled iron or steel angles, tees, beams, channels, girders and other rolled shapes or sections, weighing less than 35 lbs. per lineal yard, not punched, drilled or further manufactured than rolled, N.O.P.	"	$7 per ton.	100,413	113,945
Rolled iron or steel plates or sheets, sheared or unsheared, and skelp iron or steel, sheared or rolled in grooves, N.E.S.	"	$7 "	73,128	101,305
Carried forward				3,030,104

TABLE 9a—*Continued.*

IRON.

IMPORTS OF IRON AND STEEL GOODS.

Fiscal Year, 1899.		Duty.	Quantity.	Value.
				$
Brought forward				3,030,104
Rolled iron or steel plates, not less than 30 inches in width and not less than ¼ inch in thickness, N.O.P.	Cwt.	10 %	172,396	221,778
Rolled iron or steel sheets No. 17 gauge and thinner, N.O.P.	"	5 "	119,622	230,828
Rolls of chilled iron or steel	"	30 "	1,820	7,247
Skelp iron or steel, sheared or rolled in grooves, imported by manufacturers of wrought iron or steel pipe for use only in the manufacture of wrought iron or steel pipe in their own factories	"	5 "	215,179	223,368
Swedish rolled iron and Swedish rolled steel nail rods under half an inch in diameter for the manufacture of horse-shoe nails	"	15 "	24,283	39,383
Switches, frogs, crossings and intersections for railways	"	30 "	2,052	3,065
Steel—chrome steel	"	15 "	3,210	16,741
Steel plate, universal mill or rolled edge bridge plates imported by manufacturers of bridges	"	10 "	37,656	39,434
Steel in bars, bands, hoops, scroll or strips, sheets or plates, of any size, thickness or width when of greater value than 2½c. per lb., N.O.P.	"	5 "	108,812	272,271
Hoop iron not exceeding ⅜ of an inch in width and being No. 25 gauge and thinner, used for the manufacture of tubular rivets	"	Free.	32	310
Iron or steel beams, sheets, plates, angles, knees and cable chains for wooden, iron, steel, or composite ships or vessels	"	"	45,040	57,421
Locomotive and car wheel tires of steel, in the rough	"	"	16,051	49,134
Steel for saws and straw cutters cut to shape, but not further manufactured	"	"	10,985	74,908
Crucible sheet steel, 11 to 16 gauge, 2½ to 18 inches wide, imported by manufacturers of mower and reaper knives for manufacture of such knives in their own factories	"	"	8,574	36,533
Steel of No. 20 gauge and thinner, but not thinner than No. 30 gauge, for the manufacture of corset steels, clock springs and shoe shanks imported by the manufacturers of such articles for the exclusive use in the manufacture thereof in their own factories	"	"	2,368	7,997
Steel valued at 2½ cents per lb. and upward, imported by the manufacturers of skates, for use exclusively in the manufacture thereof in their own factories	"	"	294	1,383
Carried forward				4,301,905

IRON.

Imports

TABLE 9*a*—*Concluded.*

IRON.

IMPORTS OF IRON AND STEEL GOODS.

Fiscal Year, 1899.		Duty.	Quantity.	Value.
				$
Brought forward				4,301,905
Steel, under ½-inch in diameter, or under ½ inch square, imported by the manufacturers of cutlery, or of knobs, or of locks, for use exclusively in the manufacture of such articles in their own factories	Cwt.	Free.	1,981	4,571
Steel, No. 12 gauge and thinner, but not thinner than No. 30 gauge, for the manufacture of buckle clasps, bed fasts, furniture castors and ice creepers, imported by the manufacturers of such articles, for use exclusively in the manufacture thereof in their own factories	"	"	879	1,995
Steel of No. 24 and 17 gauge, in sheets sixty-three inches long, and from 18 inches to 32 inches wide, imported by manufacturers of tubular bow sockets for use in the manufacture of such articles in their own factories	"	"	930	2,004
Steel for International Bridge, Cornwall, (O.C.)	"	"	13,460	26,863
Steel for the manufacture of bicycle chain, imported by the manufacturers of bicycle chain for use in the manufacture thereof in their own factories	"	"	1,155	3,450
Steel for Niagara Falls Arch Bridge (O.C.)	"	"	12,000	26,552
Steel for the manufacture of files, augers, auger bits, hammers, axes, hatchets, scythes, reaping hooks, hoes, hand rakes, hay or straw knives, windmills and agricultural or harvesting forks imported by the manufacturers of such or any of such articles for use exclusively in the manufacture thereof in their own factories	"	"	50,922	89,330
Steel springs for the manufacture of surgical trusses imported by the manufacturers for use exclusively in the manufacture thereof in their own factories	"	"	139	979
Barbed fencing wire of iron and steel	"	"	169,180	316,286
Total				4,773,935

TABLE 9*b*. IRON.

IRON.

IMPORTS OF IRON AND STEEL GOODS. Imports.

Fiscal Year, 1899.		Duty.	Quantity.	Value.
				$
Agricultural implements, N.E.S., viz:				
Binding attachments	No.	20 %	103,312	32,756
Cultivators	"	20 "	2,502	17,954
Drills, grain seed	"	20 "	2,912	64,683
Farm, road or field rollers	"	25 "	5	160
Forks, pronged	"	25 "	46,997	11,005
Harrows	"	20 "	4,091	53,739
Harvesters, self binding and without binders	"	20 "	6,931	664,610
Hay tedders	"	25 "	170	4,652
Hoes	"	25 "	27,976	3,120
Horse rakes	"	20 "	4,330	69,043
Knives, hay or straw	"	25 "	213	104
" edging	"	25 "	16	23
Lawn mowers	"	35 "	2,573	6,545
Manure spreaders	"	20 "	26	697
Mowing machines	"	20 "	10,332	348,735
Ploughs	"	20 "	9,617	192,158
Post hole diggers	"	25 "	485	195
Potato diggers	"	25 "	17	307
Rakes, N.E.S	"	25 "	26,867	4,920
Reapers	"	20 "	504	25,066
Scythes and snaths, sickles or reaping hooks	Doz.	25 "	9,118	34,271
Spades and shovels and spade and shovel blanks, and iron or steel cut to shape for the same	"	35 "	7,860	27,686
Weeders	No.	20 "	7,953	56,856
All other agricultural implements, N.E.S.	$	25 "	.....	21,785
Anvils and vises	"	30 "	.....	20,132
Cart or wagon skeins or boxes	Lbs.	30 "	5,642	988
Springs, axles, axle bars, N.E.S., and axle blanks and parts thereof of iron or steel, for railway or tramway or other vehicles	Cwt.	35 "	14,793	43,867
Butts and hinges, N.E.S	$	30 "	.....	17,124
Cast iron pipe of every description	Cwt.	$8 per ton	105,914	105,573
Chains, coil chains, chain links and chain shackles of iron or steel 5-16 of an inch in diameter and over	"	5 %	31,956	60,975
Chain, malleable sprocket or link belting, for binders	$	20 "	.....	26,653
Chains, N.E.S	"	30 "	.....	25,302
Tacks, shoe	Lbs.	35 "	53,915	4,002
Cut tacks, brad sprigs, or shoe nails, double pointed, and other tacks of iron and steel, N.O.P	"	35 "	180,692	11,910
Engines, locomotives for railways, NES	No.	35 "	67	398,118
Fire	"	35 "	.....	1,733
Fire extinguishing machines	"	35 "	.....	31,197
Steam engines and boilers	"	25 "	332	107,984
Fittings, iron or steel, for iron and steel pipe	Lbs.	30 "	3,527,921	165,532
Carried forward		.....	.....	2,662,160

Iron.

Imports.

TABLE 9b—*Continued.*

IRON.

IMPORTS OF IRON AND STEEL GOODS.

Fiscal Year, 1899.		Duty.	Quantity.	Value.
				$
Brought forward				2,662,160
Forgings of iron or steel, of whatever shape or size, or in whatever stage of manufacture, N.E.S., and steel shafting, turned, compressed or polished, and hammered iron or steel bars or shapes, N.O.P.	"	30 "	2,518,063	59,738
Hardware, viz:				
Builders', cabinet-makers', upholsterers', harness-makers', saddlers' and carriage hardware, including currycombs and horse boots, N.E.S.	$	30 "		572,928
Horse, mule and ox shoes	"	30 "		12,767
Locks of all kinds	"	30 "		130,188
Machines and machinery, &c.:				
Fanning mills	No.	25 "	46	518
Grain crushers	"	25 "	16	961
Windmills	"	25 "	350	15,708
Ore crushers and rock crushers, stamp mills, cornish and belted rolls, rock drills, air compressors, cranes, derricks and percussion coal cutters	$	25 "		33,780
Portable machines:				
Fodder or feed cutters	No.	25 "	5	35
Horse powers	"	25 "	34	2,213
Portable engines	"	25 "	101	72,061
Portable saw mills and planing mills	"	25 "	11	15,779
Threshers and separators	"	25 "	178	71,738
All other portable machines	"	25 "	1,947	45,634
Parts of portable machines	$	25 "		19,099
Sewing machines and parts of	No.	30 "	7,630	158,918
Slot machines	"	25 "	293	7,811
Machines, type-writing	"	25 "	1,588	92,052
All other machinery composed wholly or in part of iron or steel, N.O.P.	$	25 "		2,293,904
Nails and spikes, composition and sheathing nails	Lbs.	15 "	30,255	2,674
Nails and spikes, wrought and pressed, trunk, clout, coopers, cigar box, Hungarian horseshoe and other nails, N.E.S.	"	30 "	264,819	8,896
Nails and spikes, cut, and railway spikes	"	½c. per lb.	925,653	16,962
Nails, wire of all kinds, N.O.P.	"	⅜c. "	388,326	10,330
Pumps, N.E.S.	$	25 "		113,816
Safes, doors for safes and vaults	"	30 "		19,319
Screws, iron and steel, commonly called "woodscrews," N.E.S.	Lbs.	35 "	217,409	17,254
Scales, balances, weighing beams and strength testing machines	$	30 "		76,673
Skates of all kinds and parts thereof	Pairs	35 "	184,166	71,610
Stoves of all kinds and parts thereof, N.E.S.	$	25 "		126,949
Stove plates, and sad or smoothing, hatters' and tailors' irons, plated wholly or in part or not	"	25 "		9,853
Carried forward				6,742,328

TABLE 9b—*Continued.* IRON.

IRON.

IMPORTS OF IRON AND STEEL GOODS. Imports.

Fiscal Year, 1899.		Duty.	Quantity.	Value.
				$
Brought forward				6,742,328
Tubing:				
Boiler tubes of wrought iron or steel, including flues and corrugated tubes for marine boilers	Lbs.	5 %	5,382,203	185,421
Tubes of rolled steel, seamless, not joined or welded, not more than 1½ inches in diameter	"	10 "	109,940	11,482
Tubes, seamless steel, for bicycles	"	10 "	746,774	58,770
Tubing, wrought iron or steel, plain or galvanized, threaded and coupled or not, over two inches in diameter, N. E.S.	"	15 "	13,253,641	293,220
Tubing, wrought iron or steel, plain or galvanized, threaded and coupled or not, 2 inches or less in diameter, N. E.S.	"	35 "	11,052,903	253,224
Other iron or steel tubes or pipes, N.O.P.	"	30 "	559,969	25,476
Ware, galvanized sheet iron or of galvanized sheet steel, manufactures of, N.O.P.	$	25 "		28,059
Ware, agate, granite or enamelled iron or steel hollow ware	"	35 "		26,356
Ware, enamelled iron or steel ware, N. E.S., iron or steel hollow ware, plain black, tinned or coated, and nickel and aluminium kitchen or household hollow ware, N.E.S	"	30 "		79,499
Wire cloth or wove wire and netting of iron or steel	Lbs.	30 "	262,003	18,161
Wire screens, doors and windows	$	30 "		4,897
Wire fencing, woven, buckthorn stiip and wire fencing of iron or steel, N.E.S.	Lbs.	15 "	708,154	23,726
Wire, single or several, covered with cotton, linen, silk, rubber or other material, &c., N.E.S.	"	30 "	3,027,575	304,608
Wire of all kinds, N.O.P	"	20 "	7,948,386	154,872
Wire rope, stranded or twisted wire, clothes lines, picture or other twisted wire and wire cables, N.E.S.	"	25 "	914,135	68,793
Iron or steel nuts, washers, rivets and bolts with or without threads and nut bolt and hinge blanks, and T. and strap hinges of all kinds, N.E.S	"	¾ c.p. lb. and 25 %	2,293,608	78,191
Pen-knives, jack-knives and pocket knives of all kinds	$	30 %		124,344
Table cutlery, all kinds, N.O.P	"	30 "		198,786
All other cutlery, N.E.S	"	30 "		131,294
Guns, rifles, including air guns and air rifles, (not being toys) muskets cannons, pistols, revolvers, or other firearms	"	30 "		123,838
Bayonets, swords, fencing foils and masks	"	30 "		1,811
Needles of any material or kind, N.O.P.	"	30 "		48,514
Carried forward				8,985,670

Iron

Imports

TABLE 9*b*—*Continued.*

IRON.

IMPORTS OF IRON AND STEEL GOODS.

Fiscal Year, 1899.		Duty.	Quantity.	Value.
				$
Brought forward	...	...	...	8,985,670
Tools and implements :				
Adzes, cleavers, hatchets, wedges, sledges, hammers, crow bars, cant dogs and track tools, picks, mattocks and eyes or poles for the same	"	30 "	.....	25,503
Axes	Doz.	25 "	9,738	41,402
Saws	$	30 "	.....	77,808
Files and rasps, N.E.S.	"	30 "	.....	76,789
Tools, hand or machine, of all kinds, N.O.P	"	30 "	.....	490,662
Knife blades, or blanks, and forks of iron or steel, in the rough not handled, filed, ground or otherwise manufactured	"	10 "	... ...	1,910
Manufactured articles or wares not specially enumerated or provided for, composed wholly or in part of iron or steel, and whether partly or wholly manufactured	"	30 "	.....	928,799
Anchors	Cwt.	Free	6,992	8,433
Iron or steel, rolled round wire rods, in the coil not over $\frac{3}{8}$-inch in diameter, imported by wire manufacturers for use in making wire in the coil in their factories	"	"	695,992	765,777
Iron or steel masts, or parts of	"	"	1,300	1,119
Rolled iron tubes not welded, or joined, under $1\frac{1}{2}$ inch in diameter, angle iron 9 and 10 gauge, not over $1\frac{1}{2}$ inch wide, iron tubing lacquered or brass covered, not over $1\frac{1}{2}$ inch diameter, all of which are to be cut to lengths for the manufacture of bedsteads, and to be used for no other purpose, and brass trimmings for bedsteads imported for the manufacture of iron or brass bedsteads	"	"	13,473	39,429
Steel bowls for cream separators and cream separators	$	"	... ...	228,721
Steel rails weighing not less than 45 lbs. per lineal yard for use only in the tracks of railways which are employed in the common carrying of goods and passengers, and are operated by steam motive power only	Cwt.	"	2,076,658	1,714,228
Steel strip and flat steel wire imported by manufacturers of buckthorn and plain strip fencing, for use in their own factories in the manufacture thereof	"	"	12,980	22,051
Steel wire, Bessemer soft drawn spring of Nos. 10, 12 and 13 gauge respectively, and homo steel spring wire of Nos. 11 and 12 gauge, respectively, imported by manufacturers of wire mattresses, to be used in their own factories in the manufacture of such articles	"	"	6,302	7,909
Carried forward	...	...	...	13,416,210

TABLE 9b—*Concluded.* IRON.

IRON.

IMPORTS OF IRON AND STEEL GOODS. Imports.

Fiscal Year, 1899.		Duty.	Quantity.	Value.
				$
Brought forward				13,416,210
Flat steel wire of No. 16 gauge or thinner imported by the manufacturers of crinoline, corset wire and dress stays, for use in the manufacture of such articles in their own factories	Cwt.	"	1,914	12,385
Flat spring steel, steel billets and steel axle bars, imported by manufacturers of carriage springs and carriage axles for use exclusively in the manufacture of springs and axles for carriages or vehicles other than railway or tramway, in their own factories	"	"	51,963	60,017
Spiral spring steel for spiral springs for railways, imported by the manufacturers of railway springs for use exclusively in the manufacture of railway spiral springs in their own factories	"	"	222,015	32,458
Wire, crucible cast steel	Lbs.	"	706,811	36,613
Galvanized iron or steel wire Nos. 9, 12 and 13 gauge	Cwt.	"	121,778	204,675
Total				13,762,358

TABLE 10.

IRON.

IMPORTS OF PIG IRON, IRON AND STEEL GOODS, ETC., FISCAL YEAR, 1898-9.

Recapitulation of Tables, 6, 7, 8, 9a and 9b.

	Tons.	Value.
Pig iron and iron kentledge	44,261	$ 452,911
Pig iron, charcoal	1,955	19,123
Scrap iron, cast	2,378	22,594
Scrap steel, wrought	28,352	301,268
Ferro-manganese, etc	1,160	22,539
Iron in slabs, blooms, puddled bars, etc	6,216	103,198
Iron and steel goods partially manufactured		4,773,935
Iron and steel goods highly manufactured*		13,762,358
Total		$19,457,926

* Machinery, etc., classed under iron and steel goods in Customs report.

Iron.

The iron industries of Canada are so well described in the annual statistical report of the American Iron and Steel Association that the following extracts have been reproduced from the report of 1899.

'On December 31, 1899, the unsold stocks of pig iron in Canada which were in the hands of the manufacturers or their agents, amounted to 9,932 tons, as compared with 9,979 tons on December 31, 1898, 20,265 tons on December 31, 1897, 29,320 tons on December 31, 1896, and 17,800 tons on December 31, 1895. Of the unsold pig iron on hand on December 31, 1899, a little less than one half was charcoal pig iron, the remainder being coke.

'On December 31, 1899, there were 9 completed blast furnaces in the Dominion, and of this number 4 were in blast and 5 were out of blast. On December 31, 1898, there were also 9 completed furnaces, of which 3 were in blast and 6 were out of blast.

'The production of Bessemer and of basic and acid open-hearth steel ingots and castings in 1899 was 22,000 gross tons, against 21,540 tons in 1898. Of the total production of open-hearth steel in 1899 about one-third was made by the acid process.

'The production of iron rails and open hearth steel rails in 1899 amounted to 835 gross tons, against 600 tons in 1898 ; structural shapes, 2,899 tons, against 1,565 tons in 1898 ; cut nails made by rolling mills and steel works having cut nail factories connected with their plants, 235,981 kegs of 100 lbs., against 152,688 kegs in 1898 ; plates and sheets 2,220 tons, against about 1,000 tons in 1898 ; all other rolled products, excluding muck and scrap bars, blooms, billets, sheet bars, etc., 94,153 tons, against 80,322 tons in 1898. Changing the cut nail production from kegs to gross tons, the total quantity of all kinds of iron and steel rolled into finished products in the Dominion in 1899, excluding muck and scrap bars, billets and other intermediate products, amounted to 110,642 tons, against 90,303 tons in 1898, 77,-021 tons in 1897, 75,043 tons in 1896, and 66,402 tons in 1895.

'The total number of completed rolling mills and steel works in Canada on December 31,1899, was 16. Of this number at least three were idle during the whole of 1899'.

LEAD.

Although the average price of lead in 1899 was much higher than in 1898, the highest in fact since 1890, the production of the metal which was derived entirely from the province of British Columbia amounted to only 21,862,436 lbs. Compared with 1898 this is a decrease of 10,052,883 lbs. or 31 per cent, and compared with 1897 the decrease is 17,155,783 lbs. or about 44 per cent.

Although many reasons will doubtless be assigned for this diminished output, the labour disputes between mine owners and workmen, and the consequent shutting down of many of the largest producers of the Slocan either partially or entirely for the greater part of the year will probably largely account for the decrease during the past year.

The statistics of production since 1887 are given in Table 1, the price per pound being the average market price of the metal for the year in New York.

TABLE 1.

LEAD.

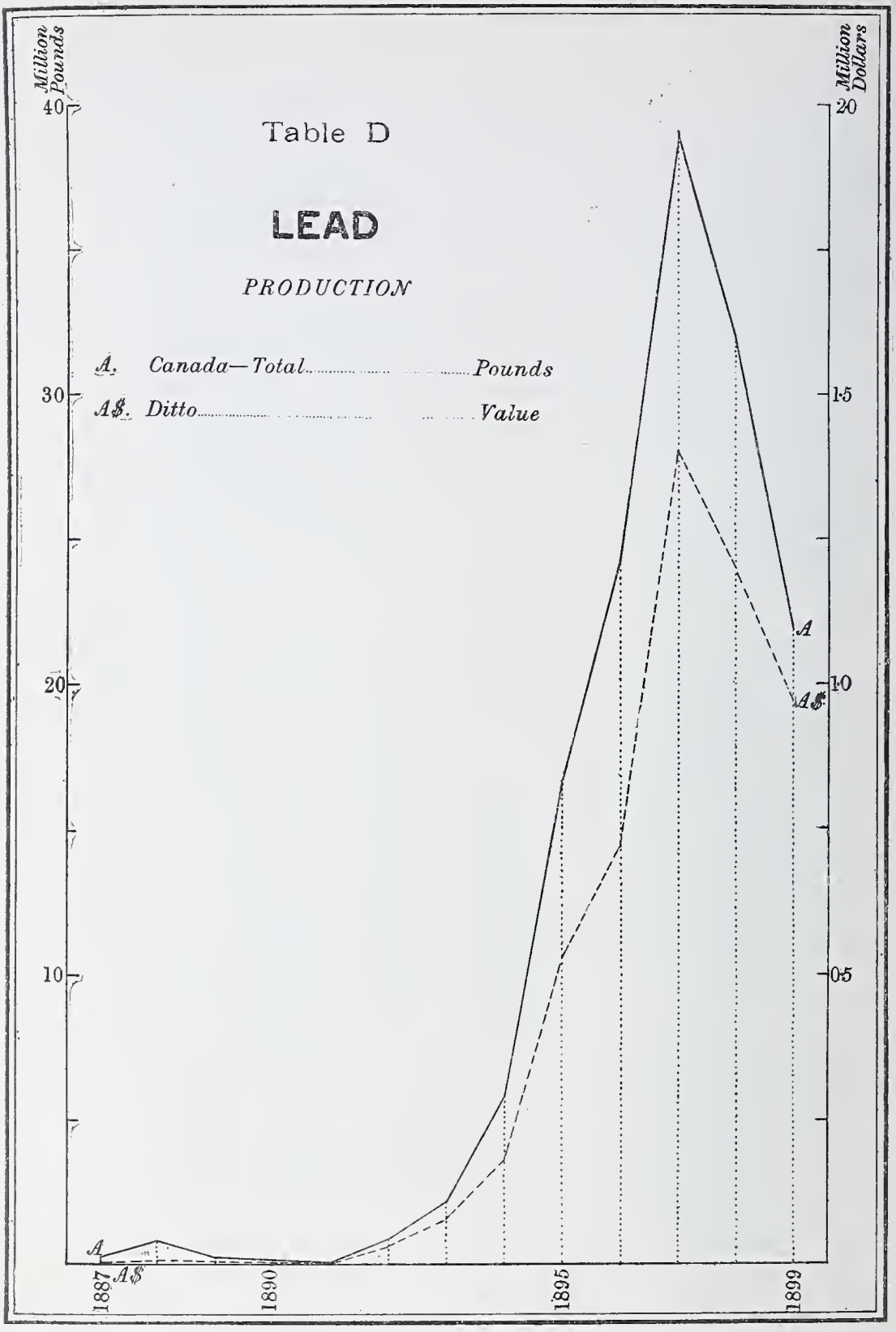
ANNUAL PRODUCTION.

Production.

Calendar Year.	Pounds.	Price per Pound.	Value.
		c.	
1887	204,800	4·50	$ 9,216
1888	674,500	4·42	29,813
1889	165,100	3·93	6,488
1890	105,000	4·48	4,704
1891	88,665	4·35	3,857
1892	808,420	4·09	33,064
1893	2,135,023	3·73	79,636
1894	5,703,222	3·29	187,636
1895	16,461,794	3·23	531,716
1896	24,199,977	2·98	721,159
1897	39,018,219	3·58	1,396,853
1898	31,915,319	3·78	1,206,399
1899	21,862,436	4·47	977,250

Previous to 1891 the greatest output was 337 tons in 1888. With the opening up of the silver-lead deposits of East and West Kootenay the production increased rapidly and from 1891 to 1897 the output jumped from 44 tons to 19,509 tons, falling away again in 1899 to 10,931 tons.

The variations in production and value are shown graphically in Table D.


Million Pounds
Million Dollars
40
30
20
10
20
15
10
05
Table D
LEAD
PRODUCTION
A. Canada—Total..... Pounds
A$. Ditto..... Value
A
A$
1887
1890
1895
1899

The value of the exports of lead in ore as furnished by the Customs Department is shown in Table 2. LEAD.

The figures for 1899 include $9,832 worth of pig lead.

TABLE 2.

LEAD.

EXPORTS. Exports.

Calendar Year.	Value.
1873	$ 1,993
1874	127
1875	7,510
1876	66
1877	720
1878	
1879	239
1880	
1881	
1882	32
1883	5
1884	36
1885	
1886	
1887	724
1888	18
1889	
1890	
1891	5,000
1892	2,509
1893	3,099
1894	144,509
1895	435,071
1896	462,095
1897	925,144
1898	885,485
1899 British Columbia	466,950

The imports of lead are shown in Tables 3 and 4, and of litharge in Table 5.

The imports of lead unmanufactured amounted in 1899 to about 7,972 tons (Table 3), while the imports of lead manufactures (Table 4) would probably be not much over 1,000 tons or say for the two classes about 9,000 tons. Besides this, however, there is a very large importation of white and red lead and orange mineral though unfortunately in the reports of Trade and Navigation since 1890, the imports of zinc white are included with the lead oxides. Previous to 1890 the statement of importation of zinc white was given separately. In 1899 the importation of dry white and red lead, orange mineral and zinc white amounted to 14,507,945 lbs. or 7,254 tons, valued at $514,842. Thus

LEAD.

Imports.

the total value of the importations of lead and manufactures of, including zinc white amounted in 1899 to $962,122.

The imports of white and red lead, etc. are given in Table 6.

TABLE 3.

LEAD.

IMPORTS OF LEAD.

Fiscal Year.	OLD, SCRAP AND PIG.		BARS, BLOCKS, SHEETS.		TOTAL.	
	Cwt.	Value.	Cwt.	Value.	Cwt.	Value.
1880	.....	.....	.....	.....	30,298	$124,117
1881	16,236	$ 56,919	18,222	$70,744	34,458	127,663
1882	36,655	120,870	10,540	35,728	47,195	156,598
1883	48,780	148,759	8,591	28,785	57,371	177,544
1884	39,409	103,413	9,704	28,458	49,113	131,871
1885	36,106	87,038	9,362	24,396	45,468	111,434
1886	39,945	110,947	9,793	28,948	49,738	139,895
1887	61,160	173,477	14,153	41,746	75,313	215,223
1888	68,678	196,845	14,957	45,900	83,635	242,745
1889	74,223	213,132	14,173	43,482	88,396	256,614
1890	101,197	283,096	19,083	59,484	120,280	342,580
1891	86,382	243,033	15,646	48,220	102,028	291,253
1892	97,375	254,384	11,299	32,368	108,674	286,752
1893	94,485	215,521	12,403	32,286	106,888	247,807
1894	70,223	149,440	8,486	20,451	78,709	169,891
1895	67,261	139,290	6,739	16,315	74,000	155,605
1896	72,433	173,162	8,575	23,169	81,008	196,331
1897	65,279	158,381	10,516	29,175	75,795	187,556
	OLD, SCRAP, PIG AND BLOCK.*		BARS AND SHEETS.†		TOTAL.	
1898	88,420	$260,779	22,214	$39,041	110,634	$299,820
1899	114,659	283,432	44,796	39,833	159,455	323,265

* Duty 15 p. c.

† Duty 25 p. c.

TABLE 4.

LEAD.

IMPORTS OF LEAD MANUFACTURES.

Fiscal Year.	Value.	Fiscal Year.	Value.
1880	$15,400	1890	$25,600
1881	22,629	1891	23,893
1882	17,282	1892	22,636
1883	25,556	1893	33,783
1884	31,361	1894	29,361
1885	36,340	1895	38,015
1886	33,078	1896	50,722
1887	19,140	1897	60,735
1888	18,816	1898	63,179
1889	16,315		

		Duty.	
1899	Lead, Tea	Free.	$46,312
	" Pipe	35 p. c.	8,008
	" Shot and bullets	35 "	2,141
	" Manufactures, N.E.S.	30 "	35,036
	Total		$91,497

TABLE 5.

LEAD.

IMPORTS OF LITHARGE.

Fiscal Year.	Cwt.	Value.
1880	3,041	$14,334
1881	6,126	22,129
1882	4,900	16,651
1883	1,532	6,173
1884	5,235	18,132
1885	4,990	16,156
1886	4,928	16,003
1887	6,397	21,865
1888	7,010	23,808
1889	8,089	31,082
1890	9,453	31,401
1891	7,979	27,613
1892	10,384	34,343
1893	7,685	24,401
1894	38,547	28,685
1895	11,955	32,953
1896	10,710	32,817
1897	12,028	34,538
1898	11,446	32,904
1899 Duty free.	9,530	32,518

Lead.

Table 6.

Lead.

Imports.

Imports of Dry White and Led Read and Orange Mineral.

Fiscal Year.	Pounds.	Value.
		$
1885	5,404,753	198,913
1886	6,703,077	213,258
1887	6,998,820	233,725
1888	6,361,334	216,654
1889	7,066,465	267,236

Imports of Dry White and Led Read, Orange Mineral and Zinc White.

Fiscal Year.	Pounds.	Value.
		$
1890	10,859,672	381,959
1891	8,560,615	337,407
1892	10,288,766	351,686
1893	10,865,183	364,680
1894	10,958,170	353,053
1895	8,780,052	282,353
1896	11,711,496	367,569
1897	10,310,463	347,539
1898	12,682,808	448,659
1899 Duty 5 p.c.	14,507,945	514,842

British Columbia.

British Columbia.

The production of lead in British Columbia since 1887 is shown in Table 7 below.

Table 7.

Lead.

British Columbia : Production.

Calendar Year.	Pounds.	Price per Pound.	Value.
		cts.	
1887	204,800	4·50	$ 9,216
1888	674,500	4·42	29,813
1889	165,100	3·93	6,488
1890	Nil.		
1891	"		
1892	808,420	4·09	33,064
1893	2,131,092	3·73	79,490
1894	5,703,222	3·29	187,636
1895	16,461,794	3.23	531,716
1896	24,199,977	2·98	721,159
1897	38,841,135	3·58	1,390,513
1898	31,693,559	3·78	1,198,017
1899	21,862,436	4·47	977,520

The various subdivisions of East and West Kootenay, from which the production was all derived, contribute as follows to the output for 1899. LEAD. British Columbia.

Fort Steele, 4 per cent. Nelson over 2·5 per cent, Ainsworth over 16 per cent, and the Slocan a little over 76 per cent.

MANGANESE.

MANGANESE.

Owing chiefly to the operations of the Mineral Products Company, at Dawson Settlement, in New Brunswick, the production of manganese in 1889 reached a total of 1,581 tons, valued at $20,004, the largest production recorded since 1890.

The statistics of production since 1886, showing the average value per ton, are given in Table 1.

TABLE 1.

MANGANESE.

ANNUAL PRODUCTION. Production.

Calendar Year.	Tons.	Value.	Value per ton.
1886	1,789	$41,499	$23.20
1887	1,245	43,658	35.07
1888	1,801	47,944	26.62
1889	1,455	32,737	22 50
1890	1,328	32,550	24.51
1891	255	6,694	26.25
1892	115	10,250	89.13
1893	213	14,578	68.44
1894	74	4,180	56.49
1895	125	8,464	67.71
1896*	123½	3,975	32.19
1897*	15¼	1,166	76.46
1898	50	1,600	32·00
1899	1,581	20,004	12·65

* Exports.

It will be seen that the production of past years has varied much in grade of ore shipped. The average value per ton in 1899 was only $12.65 while in past years it has gone as high as $89.

In Nova Scotia, Mr. Miner T. Foster continued work at the New Ross deposit, Lunenburg county.

From the Jordan Mountain mine, King's county, New Brunswick, a quantity of ore was shipped to Bridgeville, N.S., and operations

MANGANESE. Exports.

were continued on the bog manganese deposit at Dawson Settlement, Albert county, by the Mineral Products Company.

This bog or "wad" manganese is first dried, then mixed with a suitable binder and shipped in the form of cylindrical bricks 3 inches in diameter and $2\frac{1}{2}$ inches long.

The exports of manganese are given in Table 2, and the imports of oxide of manganese in Table 3.

TABLE 2.

MANGANESE.

EXPORTS OF MANGANESE ORE.

CALENDAR YEAR.	NOVA SCOTIA.		NEW BRUNSWICK.		TOTAL.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
1873	.....	.....	1,031	$20,192	1,031	$20,192
1874	6	$ 12	776	16,961	782	16,973
1875	.....	200	194	5,314	203	5,514
1876	21	723	391	7,316	412	8,039
1877	106	3,699	785	12,210	891	15,909
1878	106	4,889	520	5,971	626	10,860
1879	154	7,420	1,732	20,016	1,886	27,436
1880	79	3,090	2,100	31,707	2,179	34,797
1881	200	18,022	1,504	22,532	1,704	40,554
1882	123	11,520	771	14,227	894	25,747
1883	313	8,635	1,013	16,708	1,326	25,343
1884	134	1,054	469	9,035	603	20,089
1885	77	5,054	1,607	29,595	1,684	34,649
1886	(a) 441	854	1,377	27,484	(a)1,818	58,338
1887	578	14,240	837	20,562	1,415	34,802
1888	87	5,759	1,094	16,073	1,181	21,832
1889	59	3,024	1,377	26,326	1,436	29,350
1890	177	2,583	1,729	34,248	1,906	36,831
1891	22	563	233	6,131	255	6,694
1892	84	6,180	59	2,025	143	8,205
1893	123	12,409	10	112	133	12,521
1894	11	720	45	2,400	56	3,120
1895	108	6,348	$\frac{3}{10}$	3	$108\frac{3}{10}$	6,351
1896	$123\frac{1}{2}$	3,975	.....	.....	$123\frac{1}{2}$	3,975
1897	$15\frac{1}{4}$	1,166	.....	.....	$15\frac{1}{4}$	1,166
1898	11	325	.....	.....	11	325
1899	67	2,328	3	82	70	2,410

(a) 250 tons from Cornwallis should more correctly be classed under the heading of mineral pigments.

Table 3.

Manganese.

Imports: Oxide of Manganese.

Manganese.

Imports.

Fiscal Year.	Pounds.	Value.
1884	3,989	$ 258
1885	36,778	1,794
1886	44,967	1,753
1887	59,655	2,933
1888	65,014	3,022
1889	52,241	2,182
1890	67,452	3,192
1891	92,087	3,743
1892	76,097	3,530
1893	94,116	3,696
1894	101,863	4,522
1895	64,151	2,781
1896	108,590	4,075
1897	70,663	2,741
1898	130,456	5,047
1899 Duty free	141,356	5,539

MERCURY.

Mercury.

There has been no output of mercury reported since 1897. The small output for the years 1895, 1896 and 1897 was obtained from the cinnabar mines in the vicinity of Kamloops Lake, B.C.

Table 1.

Mercury.

Production.

Production.

Calendar Year.	Flasks, (76½ lbs.)	Price per flask.	Value.
1895	71	$ 33 00	$ 2,343
1896	58	33 44	1,940
1897	9	36 00	324

Mercury.

Table 2.
Mercury.
Imports.

Imports.

Fiscal Year.	Pounds.	Value.
1882.	2,443	$ 965
1883.	7,410	2,991
1884.	5,848	2,441
1885.	14,490	4,781
1886.	13,316	7,142
1887.	18,409	10,618
1888.	27,951	14,943
1889.	22,931	11,844
1890.	15,912	7,677
1891.	29,775	20,223
1892.	30,936	15,038
1893.	50,711	22,998
1894.	36,914	14,483
1895.	63,732	25,703
1896	77,869	32,343
1897.	76,058	33,534
1898	59,759	36,425
1899 Duty free.	103,017	51,695

Mica.

MICA.

The production of mica has been calculated according to the practice followed during the past few years viz: of adding to the known exports an estimate of the value of the home consumption.

On this basis the production of 1899 was valued at $163,000, an increase over the production of 1898 of $44,625 or nearly 38 per cent.

Statistics of production and exports are given in Tables 1 and 2 following.

Table 1.
Mica.
Annual Production.

Production.

Calendar Year.	Value.
1886.	$ 29,008
1887.	29,816
1888.	30,207
1889.	28,718
1890.	68,074
1891.	71,510
1892.	104,745
1893.	75,719
1894.	45,581
1895.	65,000
1896.	60,000
1897.	76,000
1898.	118,375
1899	163,000

TABLE 2.

MICA.

EXPORTS.

MICA, Exports.

Calendar Year.	Value.
1887	$ 3,480
1888	23,563
1889	30,597
1890	22,468
1891	37,590
1892	86,562
1893	70,081
1894	38,971
1895	48,525
1896	47,756
1897	69,101
1898	110,507
1899	153,002

The mica marketed is chiefly the product of mines in the provinces of Ontario and Quebec, in the district about Ottawa, and is practically all of the phlogopite and biotite varieties.

Within the past two years however, some developments have taken place in occurrences of mica at Tête Jaune Cache in British Columbia. The mica here is a transparent muscovite of excellent quality. Messrs. Samuel Winter & Company of Moncton, New Brunswick, have been doing some prospecting work in the locality and during 1899, they shipped several hundred pounds, valued at from 50 cents to $1 per pound, besides leaving some tons of marketable mica in the dump.

MINERAL PIGMENTS.

MINERAL PIGMENTS.

Under this heading is included the production of ochres and baryta.

Ochres.—The production of ochres in 1899 amounted to 3,919 tons valued at $20,000, a considerable increase over the previous year, and the largest quantity recorded in the table of production.

The product mined is almost entirely from the ochre deposits near Three Rivers, Champlain county, Quebec. In Ontario however there was a small production, in Nelson township, Halton county, where a few tons are yearly mined by the Ontario Mineral Paint Works, for use in the manufacture of their "fire proof paints."

At St. Malo near Three Rivers, Quebec, the Canada Paint Company and the Champlain Oxide Co., continued operations with increased

Mineral Pigments.

output, while Thos. H. Argall continues to ship crude ochre to gas companies in both Canada and the United States.

Production.

Table 1.
Mineral Pigments.
Annual Production of Ochres.

Calendar Year.	Tons.	Value.
1886	350	$ 2,350
1887	485	3,733
1888	397	7,900
1889	794	15,280
1890	275	5,125
1891	900	17,750
1892	390	5,800
1893	1,070	17,710
1894	611	8,690
1895	1,339	14,600
1896	2,362	16,045
1897	3,905	23,560
1898	2,226	17,450
1899	3,919	20,000

Imports.

Table 2.
Mineral Pigments.
Imports of Ochres.

Fiscal Year.		Pounds.	Value.
1880		571,454	$ 6,544
1881		677,115	8,972
1882		731,526	8,202
1883		898,376	10,375
1884		533,416	6,398
1885		1,119,177	12,782
1886		1,100,243	12,267
1887		1,460,128	17,067
1888		1,725,460	17,664
1889		1,342,783	12,994
1890		1,394,811	14,066
1891		1,528,696	20,550
1892		1,708,645	22,908
1893		1,968,645	23,134
1894		1,358,326	18,951
1895		793,258	12,048
1896		1,159,494	16,954
1897		1,504,044	18,504
1898		2,126,592	26,307
	Duty.		
1899 — Ochres, ochrey earths and raw siennas	20 p. c.	1,107,600	$ 10,432
1899 — Oxides, fire-proofs, umbers and burnt siennas, N.E.S.	25 "	1,337,098	20,660
Total, 1899		2,444,698	$31,092

The exports of mineral pigments, iron oxides, etc., for the past three years has been :— Mineral Pigments.

Imports.

	Tons.	Value.
1897	512	$7,706
1898	283	4,227
1899	308	5,408

Baryta.—The statistics of production of baryta are given in Table 3. The figures for 1899, 720 tons valued at $4,402, show a decrease from the production of 1898. The mining of the mineral has been of an exceedingly irregular character, as will be evident from the table.

Table 3.

Mineral Pigments.

Annual Production of Baryta. Production of Baryta.

Calendar Year.	Tons.	Value.
1885	300	$ 1,500
1886	3,864	19,270
1887	400	2,400
1888	1,100	3,850
1889	....	.....
1890	1,842	7,543
1891	.....	.....
1892	315	1,260
1893	....	.....
1894	1,081	2,830
1895	.....	.....
1896	145	715
1897	571	3,060
1898	1,125	5,533
1899	720	4,402

Shipments were made during the year from Lake Ainslie, Inverness county and from Brookfield, Colchester county, Nova Scotia, by Messrs. Henderson and Potts of Halifax. The Canada Paint Company mined several hundred tons near Cantley, Wright county, Quebec.

Mineral Pigments.

Imports.

Table 4.

Mineral Pigments.

Imports of Baryta.

Fiscal Year.	Cwt.	Value.
1880	2,230	$1,525
1881	3,740	1,011
1882	497	303
1883		185
1884		229
1885	7	14
1886		62
1887	379	676
1888	236	214
1889	1,332	987
1890	1,322	978

Table 5.

Mineral Pigments.

Miscellaneous Imports, Fiscal Year, 1899.

——	Duty.	Quantity.	Value.
			$
Paint, ground or mixed in, or with either japan, varnish, lacquers, liquid dryers, collodion, oil finish or oil varnish ..... Lbs.	25 p. c.	68,461	4,918
Paints and colours, and rough stuff and fillers, anti-corrosive and anti-fouling paints commonly used for ship hulls, N.E.S ..... "	25 "	83,813	5,200
Paris green, dry ..... "	10 "	232,887	25,051
Paints and colours ground in spirits, and all spirit varnishes and lacquers ... ... Galls.	$1.12½ per gallon ..	441	1,543
Putty ..... Lbs.	20 p. c.	335,560	4,59
Total	.....	.....	41,311

Mineral Water.

MINERAL WATER

Mineral springs are known to occur at many places throughout Canada, and at quite a number the water is being utilized, either put up in bottles for sale throughout the country or used for drinking or bathing purposes at the places where it is found. At several points hotels have been erected at which the guests have the privilege of using the mineral water at the place. In view of this it is difficult to obtain statistics giving an intelligent idea of the extent or value of the industry.

The value of the sales of mineral water in 1899 has been estimated at about $100,000. Mineral Water.

The statistics of production for past years as per returns from individuals and companies operating the springs, are given in Table 1, while the imports of mineral water are given in Table 2. Production.

TABLE 1.

MINERAL WATERS.

ANNUAL PRODUCTION.

Calendar Year.	Gallons.	Value.
1888	124,850	$ 11,456
1889	424,600	37,360
1890	561,165	66,031
1891	427,485	54,268
1892	640,380	75,348
1893	725,096	108,347
1894	767,460	110,040
1895	739,382	126,048
1896	706,372	111,736
1897	749,691	141,477
1898	555,000	100,000
1899		100,000

TABLE 2.

MINERAL WATERS.

IMPORTS. Import

Fiscal Year.	Value.	Fiscal Year.	Value.
1880	$15,721	1890	40,802
1881	17,913	1891	41,797
1882	27,909	1892	55,763
1883	28,130	1893	57,953
1884	27,879	1894	49,546
1885	32,674	1895	48,613
1886	22,142	1896	55,864
1887	33,314	1897	47,006
1888	38,046	1898	52,989
1889	30,343		
1899 Mineral waters, natural, not in bottle ... Duty free ..			$ 1,286
1899 Mineral and ærated waters ... " 20 p.c.			53,605
Total			$54,891

Natural Gas.

NATURAL GAS.

According to the returns received from the various operators, the total value of the sale of natural gas in 1899 was $387,271, an increase over the value of 1898 of $65,148 or over 20 per cent. Practically all the gas sold is obtained from the wells in southern Ontario, the gas found in the North-west Territories not yet having been put to any extended use.

Statistics of production are given in Table 1.

Table 1.

Natural Gas.

Annual Production.

Production.

Calendar Year.	Value.
1892	$ 150,000
1893	376,233
1894	313,754
1895	423,032
1896	276,301
1897	325,873
1898	322,123
1899	387,271

There is nothing new to report concerning the Ontario fields, for complete description of which the reader is referred to the report of the Section for 1898.

Nickel.

NICKEL.

The production of nickel from the Sudbury ores, which continue to be the source of Canada's nickel output, amounted in 1899 to 5,744,000 lbs. or 2,872 tons, which at the average price for refined nickel in New York was worth $2,067,840. Compared with 1898 this is an increase of 226,310 lbs. or 4 per cent. in quantity and $247,002 or 13·5 per cent. in value. The price of the metal increased during the latter part of the year averaging about 40 cents per lb. during December.

The quantity of ore treated was 172,761 tons, so that the nickel contents averaged about 1·66 per cent. In 1898 the nickel averaged 2·26 per cent of the ore and in 1897, 2·08 per cent.

The statistics of nickel production since 1889 are given in Table 1 below, the variations being shown graphically in Table E.

TABLE 1. NICKEL.

NICKEL.

ANNUAL PRODUCTION. Production.

Calendar Year.	Pounds of nickel in matte.	Price per lb.	Value.
1889	*830,477	60c.	$ 498,286
1890	1,435,742	65c.	933,232
1891	4,626,627	60c.	2,775,976
1892	2,413,717	58c.	1,399,956
1893	3,982,982	52c.	2,071,151
1894	4,907,430	38⅛c.	1,870,958
1895	3,888,525	35c.	1,360,984
1896	3,397,113	35c.	1,188,990
1897	3,997,647	35c.	1,399,176
1898	5,517,690	33c.	1,820,838
1899	5,744,000	36c.	2,067,840

* Calculated from shipments made by rail.

The value of the exports according to the returns made to the Customs Department are given in Table 2, and the imports of nickel in Table 3.

TABLE 2.

NICKEL.

EXPORTS.* Exports.

Calendar Year.	Value.
1890	$ 89,568
1891	667,280
1892	293,149
1893	629,692
1894	559,356
1895	521,783
1896	658,213
1897	723,130
1898	1,019,363
1899	939,915

* Practically all the nickel-bearing ore and matte produced in Canada is exported, the apparent discrepancy between Tables Nos. 1 and 2 being due to the different basis of valuation adopted in the two instances. Table 1 represents the total final values of the nickel produced in Canada, for the years represented. In Table 2 the worth of the product shipped is entered at its spot value to the operators, and depends upon the particular stage to which they happened to carry the process of extraction at the time *e.g.*, whether the shipments made are raw ore, low grade matte or high grade matte, etc.

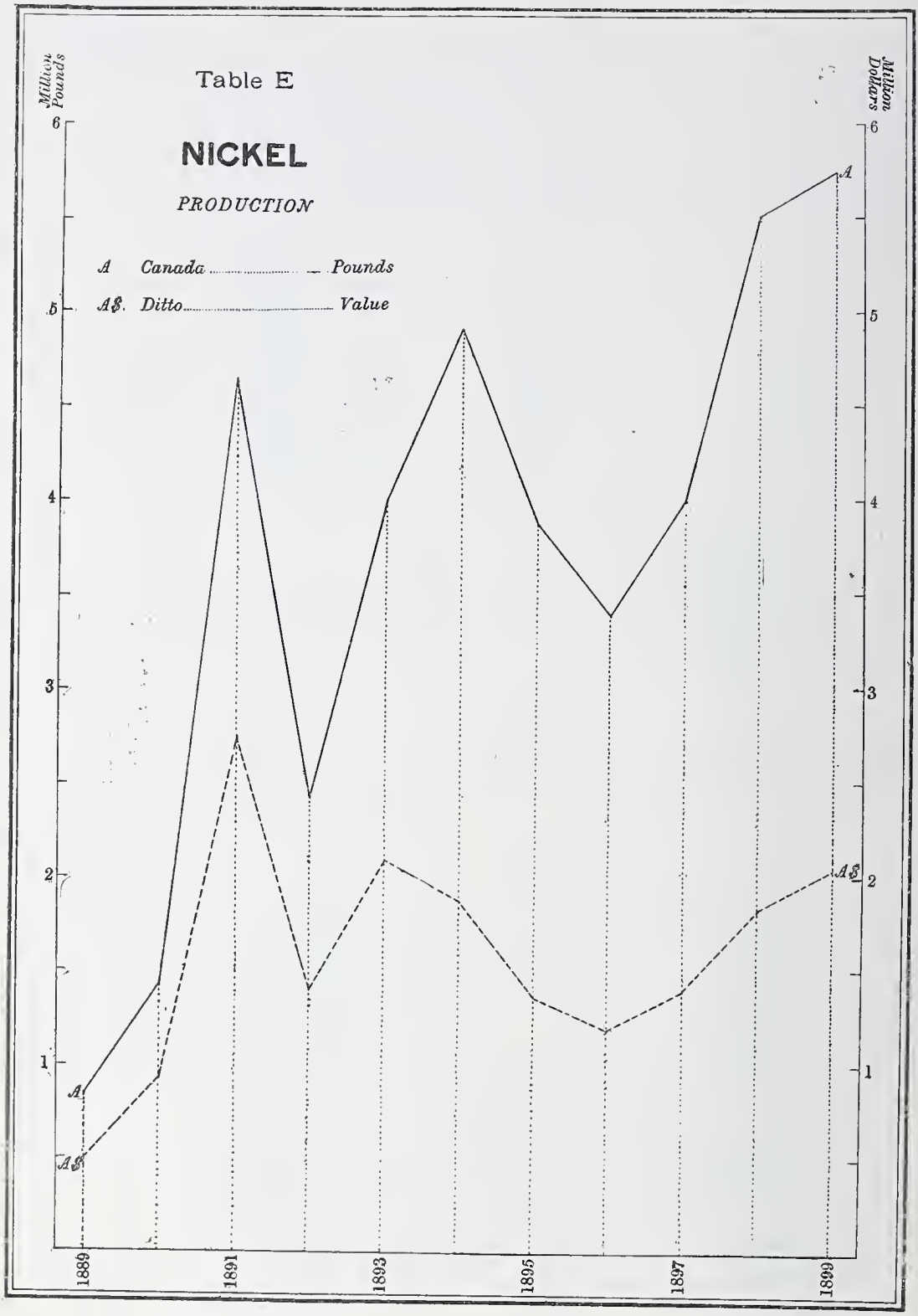


Table E
NICKEL
PRODUCTION
A Canada ..... Pounds
A$. Ditto ..... Value
Million Pounds
Million Dollars
6
5
4
3
2
1
A
A$
1889
1891
1893
1895
1897
1899

Table 3.
Nickel.
Imports.

Nickel.
Imports.

Fiscal Year.		Duty.	Value.
1890			$ 3,154
1891			3,889
1892			3,208
1893			2,905
1894			3,528
1895			4,267
1896			4,787
1897			4,737
1898			5,882
1899	Nickel anodes	10 p. c.	9,445
	Nickel	Free.	4
			$ 9,449

PETROLEUM.

Petroleum.

The oil refining industry is still confined to the oil fields of southern Ontario.

The consolidation of the various refining industries in 1898 under the name of the Imperial Oil Company, was recorded in the report of this Section for that year. In the same report will be found a description of the chief features of the industry and of the different oil fields, accompanied by a sketch map, showing the oil areas.

There is little variation to report in the statistics of production. The figures of production, as deduced from the inspection returns of the Inland Revenue Department, have already been given in the Summary of the Mineral Production of Canada. The total quantity of refined oils inspected was 11,929,981 galls. Assuming the ratio of crude to refined to be 100 to 42, this is equivalent to 28,399,955 gallons of crude oil or 808,570 barrels of 35 gallons. The average price paid for the oil for the year was $\$1.48\frac{2}{3}$ an increase over the average price for 1898 of $8\frac{2}{3}$ cents, making a total value for the year of $1,202,020. Tables 1 and 2 give the output of refined products according to direct returns from the refiners for the year 1896, 1897 and 1898. Owing to the confidential nature of the returns, we are unable to give the corresponding figures for the year 1899.

PETROLEUM.

Production.

TABLE 1.

PETROLEUM.

PRODUCTION OF CANADIAN OIL REFINERIES.

Products.	Calendar Years.					
	1896.		1897.		1898.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
		$		$		$
Illuminating oils.galls.	11,207,150	1,251,122	10,493,449	1,064,130	11,804,667	1,189,871
Benzine and naphtha ... . "	719,453	70,733	747,163	71,978	1,229,407	120,651
Paraffine oils... . "	1,014,271	132,308	930,490	136,283	850,863	114,191
Gas and fuel oils "	6,788,353	261,618	6,723,683	249,615	6,399,298	245,101
Lubricating oils and tar.. ..... "	1,447,455	77,109	1,148,847	62,058	868,957	53,479
Paraffine wax.... lbs.	1,532,670	76,249	1,805,365	81,191	2,522,834	101,972
Axle grease..... "	318,928	7,774	227,079	7,174	... .	.....
Totals.....	.....	1,876,913	.....	1,672,429	.. ..	1,825,265

TABLE 2.

PETROLEUM.

CONSUMPTION OF CRUDE OIL AND CHEMICALS.

Articles.	Calendar Years.			
	1895.	1896.	1897.	1898.
Crude petroleum .....galls.	24,954,855	25,881,095	25,488,230	25,933,807
Sulphuric acid ..... lbs.	4,919,271	5,146,429	5,504,411	6,761,439
Soda.. .. .. "	390,781	438,058	479,660	446,529
Litharge .... "	390,573	361,603	504,227	211,546
Sulphur .. .. "	78,597	80,612	65,349	35,014

The quantity of Canadian refined oil inspected in 1899 has already been mentioned. Table 3 gives similar statistics for past years. In Table 4 which is for the fiscal year, the amounts both of Canadian and imported oil inspected are exhibited side by side, and the percentages of each shown.

TABLE 3.

PETROLEUM.

CANADIAN OILS AND NAPHTHA INSPECTED AND CORRESPONDING QUANTITIES OF CRUDE OIL.

Calendar Year.	Refined Oils Inspected.	Crude Equivalent Calculated.	Ratio of Crude to Refined.	Equivalent in Barrels of 35 Gallons	Average Price per Barrel of Crude.	Value of Crude Oil.
	Galls.	Galls.				
1881	6,457,270	12,914,540	100 : 50	368,987	.....	.....
1882	6,135,782	13,635,071	100 : 45	389,573	.....	.....
1883	7,447,648	16,550,328	100 : 45	472,866	.....	.....
1884	7,993,995	19,984,987	100 : 40	571,000	.....	.....
1885	8,225,882	20,564,705	100 : 40	587,563	.....	.....
1886	7,768,006	20,442,121	100 : 38	584,061	$0.90	$525,655
1887	9,492,588	24,980,494	100 : 38	713,728	0.78	556,708
1888	9,246,176	24,332,042	100 : 38	695,203	1.02$\frac{2}{3}$	713,695
1889	9,472,476	24,664,144	100 : 38	704,690	0.92$\frac{1}{4}$	653,600
1890	10,174,894	26,776,037	100 : 38	795,030	1.18	902,734
1891	10,065,463	26,435,430	100 : 38	755,298	1.33$\frac{1}{3}$	1,010,211
1892	10,370,707	27,291,334	100 : 38	779,753	1.26$\frac{1}{4}$	984,438
1893	10,618,804	27,944,221	100 : 38	798,406	1.09$\frac{1}{2}$	874,255
1894	11,027,982	29,018,637	100 : 38	829,104	1.00$\frac{5}{6}$	835,322
1895	10,674,232	25,414,838	100 : 42	726,138	1.49$\frac{1}{2}$	1,086,738
1896	10,684,284	25,438,771	100 : 42	726,822	1.59	1,155,647
1897	10,434,878	24,844,995	100 : 42	709,857	1.42$\frac{1}{2}$	1,011,546
1898	11,148,348	26,543,685	100 : 42	758,391	1.40	1,061,747
1899	11,927,981	28,399,955	100 : 42	808,570	1·48$\frac{2}{3}$	1,202,020

TABLE 4.

PETROLEUM.

TOTAL AMOUNT OF OIL INSPECTED, CANADIAN AND IMPORTED.

Fiscal Year.	Canadian.	Imported.	Total.	Canadian.	Imported.
	Galls.	Galls.	Galls.	%	%
1881	6,406,783	476,784	6,883,567	93·1	6·9
1882	5,910,747	1,351,412	7,262,159	81·4	18·6
1883	6,970,550	1,190,828	8,161,378	85·4	14·6
1884	7,656,001	1,142,575	8,798,586	87·0	13·0
1885	7,661,617	1,278,115	8,939,732	85·7	14·3
1886	8,149,472	1,327,616	9,477,088	86·0	14·0
1887	8,243,962	1,665,604	9,909,566	83·2	16·8
1888	9,545,895	1,821,342	11,367,237	84·0	16·0
1889	9,462,834	1,767,812	11,230,646	84·3	15·7
1890	10,121,210	2,020,742	12,141,952	83·4	16·6
1891	10,270,107	2,022,002	12,292,109	83·6	16·4
1892	10,238,426	2,429,445	12,667,871	80·8	19·2
1893	10,683,806	2,641,690	13,325,496	80·2	19·8
1894	10,824,270	5,633,222	16,457,492	65·8	34·2
1895	10,936,992	5,650,994	16,587,986	65·9	34·1
1896	10,533,951	5,807,991	16,341,942	64·5	35·5
1897	10,506,526	6,248,743	16,755,269	62·7	37·3
1898	10,796,847	6,880,724	17,677,581	61·1	38·9
1899	11,005,804	7,232,348	18,238,152	60·3	39·7

PETROLEUM.

Exports.

The totals of this latter table practically represent the consumption of refined petroleum in Canada. It will be seen that the proportion of imported oils has been slowly but steadily increasing.

Tables 5, 6, 7, 8 and 9, give the exports and imports of petroleum and its products as obtained from the Trade and Navigation Reports.

TABLE 5.

PETROLEUM.

EXPORTS OF CRUDE AND REFINED PETROLEUM.

Calendar Year.	Crude Oil.		Refined Oil.		Total.	
	Gallons.	Value.	Gallons.	Value.	Gallons.	Value.
1881					501	$ 99
1882					1,119	286
1883					13,283	710
1884					1,098,090	30,168
1885					337,967	10,562
1886					241,716	9,855
1887					473,559	13,831
1888					196,602	74,542
1889					235,855	10,777
1890					420,492	18,154
1891	446,770	$ 18,471	585	$104	447,355	18,575
1892	310,387	12,945	1,146	100	311,533	13,045
1893	107,719	3,696	2,196	394	109,915	4,090
1894	53,985	2,773	5,297	513	59,282	3,286
1895	22,831	1,044	10,237	2,023	33,068	3,067
1896	601	101	7,489	999	8,090	1,100
1897			342	49	342	49
1898	96	4	12,735	3,001	12,831	3,005
1899			3,425	859	3,425	859

TABLE 6.

PETROLEUM.

IMPORTS OF PETROLEUM AND PRODUCTS OF.

Fiscal Year.	Gallons.	Value.	Fiscal Year.	Gallons.	Value.
		$			
1880	687,641	131,359	1890	5,075,650	515,852
1881	1,437,475	262,168	1891	5,071,386	498,330
1882	3,007,702	398,031	1892	5,649,145	475,732
1883	3,086,316	358,546	1893	6,002,141	446,389
1884	3,160,282	380,082	1894	6,597,108	439,988
1885	3,767,441	415,195	1895	7,577,674	525,372
1886	3,819,146	421,836	1896	8,005,891	735,913
1887	4,290,003	467,003	1897	8,415,302	697,169
1888	4,523,056	408,025	1898	9,074,311	724,519
1889	4,650,274	484,462			

		Duty.		
1899	Oils: Mineral—			
	(*a*) Coal and kerosene, distilled, purified or refined, naphtha and petroleum, N.E.S.	5c. p. gall.	9,363,439	659,452
	(*b*) Products of petroleum	5c. "	40,995	5,896
	(*c*) Crude petroleum, fuel and gas oils (other than naphtha, benzine or gasoline) when imported by manufacturers (other than oil refiners) for use in their own factories, for fuel purposes or for the manufacture of gas	2½c. "	290,264	12,452
	(*d*) Illuminating oils composed wholly or in part of the products of petroleum, coal, shale or lignite, costing more than 30 cents per gallon	25 p. c.	13,491	4,647
	(*e*) Lubricating oils composed wholly or in part of petroleum, costing less than 25 cents per gallon	5c. p. gall.	686,019	80,856
			10,394,208	763,303

TABLE 7.*

PETROLEUM.

IMPORTS OF CRUDE AND MANUFACTURED OILS, OTHER THAN ILLUMINATING.

Fiscal Year.	Gallons.	Fiscal Year.	Gallons,
1881	960,691	1891	3,049,384
1882	1,656,290	1892	3,047,199
1883	1,895,488	1893	1,481,749
1884	2,017,707	1894	1,860,829
1885	2,489,326	1895	1,106,907
1886	2,491,530	1896	1,079,940
1887	2,624,399	1897	800,411
1888	2,701,714	1898	1,046,493
1889	2,882,462	1899	727,014
1890	3,054,908		

* This table is composed of items (*b*) and (*e*) of Table 6.

PETROLEUM.

Imports.

TABLE 8.

PETROLEUM.

IMPORTS OF PARAFFINE WAX.

Fiscal Year.	Pounds.	Value.
1883	43,716	$ 5,166
1884	39,010	6,079
1885	59,967	8,123
1886	62,035	7,953
1887	61,132	6,796
1888	53,862	4,930
1889	63,229	5,250
1890	239,229	15,844
1891	753,854	50,275
1892	733,873	48,776
1893	452,916	38,935
1894	208,099	15,704
1895	163,817	11,579
1896	150,287	10,042
1897	138,703	7,945
1898	103,570	5,987
1899 (Duty, 30 p. c.)	92,242	4,025

TABLE 9.

PETROLEUM.

IMPORTS OF PARAFFINE WAX CANDLES.

Fiscal Year.	Pounds.	Value.
1880	10,445	$2,269
1881	7,494	1,683
1882	5,818	1,428
1883	7,149	1,734
1884	8,755	2,229
1885	9,247	2,449
1886	12,242	2,587
1887	21,364	3,611
1888	22,054	2,829
1889	8,038	1,337
1890	7,233	1,186
1891	10,598	2,116
1892	9,259	1,952
1893	8,351	1,735
1894	10,818	1,685
1895	19,448	2,541
1896	25,787	4,072
1897	25,114	2,929
1898	60,802	4,427
1899... Duty 30 p.c.	62,331	5,856

The average monthly prices for crude oil at Petrolia from 1893 to 1899 are given in Table 10 following.

TABLE 10. PETROLEUM.

PETROLEUM.

Prices.

AVERAGE MONTHLY PRICES FOR CRUDE OIL AT PETROLIA.

MONTH.	CALENDAR YEAR.						
	1893.	1894.	1895.	1896.	1897.	1898.	1899.
	$	$	$	$	$	$	$
January	1.18¼	1.01¼	1.16	1.72	1.50	1.40	1.40
February	1.18¾	1.01	1.19⅞	1.72	1.50	1.40	1.40
March	1.19	1.01	1.27	1.72	1.50	1.40	1.40
April	1.19	.99½	1.55¾	1.72	1.40	1.40	1.43
May	1.07	.92	1.67¼	1.70	1.40	1.40	1.45
June	1.07	.92¾	1.52	1.50	1.40	1.40	1.45
July	1.06	.94	1.54¼	1.50	1.40	1.40	1.45
August	1.05	.96	1.54	1.50	1.40	1.40	1.46½
September	1.04½	.98	1.55½	1.50	1.40	1.40	1.52½
October	1.04	1.06	1.59⅞	1.50	1.40	1.40	1.57
November	1.04	1.12¼	1.64½	1.50	1.40	1.40	1.63½
December	1.02	1.13½	1.72⅜	1.50	1.40	1.40	1.66½
The Year	1.09½	1.00¾	1.49⅔	1.59	1.42½	1.40	1.48⅔

PHOSPHATE *(Apatite)*.

PHOSPHATE.

The production of phosphate in 1899 reached a total of 3,000 tons, estimated from railway shipments. This is the largest production since 1894, and is derived from various points in Ontario and Quebec. As pratically none of the apatite mines are now being worked as such, the production represents the small quantities of that mineral, stocks of which are accumulated as a by-product, obtained in mining for mica. A little is perhaps also obtained in working over old dumps at the abandoned phosphate mines.

PHOSPHATE.

Statistics of production and exports are given in Tables 1 and 2.

Production.

TABLE 1.

PHOSPHATE.

ANNUAL PRODUCTION.

Calendar Year.	Tons.	Average Value per ton.	Value.
1886	20,495	$14.85	$304,338
1887	23,690	13.50	319,815
1888	22,485	10.77	242,285
1889	30,988	10.21	316,662
1890	31,753	11.37	361,045
1891	23,588	10.24	241,603
1892	11,932	13.20	157,424
1893	8,198	8.65	70,942
1894	6,861	6.00	41,166
1895	1,822	5.25	9,565
1896	570	6.00	3,420
1897	908	4.39	3,984
1898	733	5·00	3,665
1899	3,000	6·00	18,000

TABLE 2.

PHOSPHATE.

Exports.

EXPORTS.

Calendar Year.	Ontario.		Quebec.		Totals.	
	Tons.	*Value.	Tons.	*Value.	Tons.	*Value.
1878	824	$12,278	9,919	$195,831	10,743	$208,109
1879	1,842	20,565	6,604	101,470	8,446	122,035
1880	1,387	14,422	11,673	175,664	13,060	190,086
1881	2,471	36,117	9,497	182,339	11,968	218,456
1882	568	6,338	16,585	302,019	17,153	308,357
1883	50	500	19,666	427,168	19,716	427,668
1884	763	8,890	20,946	415,350	21,709	424,240
1885	434	5,962	28,535	490,331	28,969	496,293
1886	644	5,816	19,796	337,191	20,460	343,007
1887	705	8,277	22,447	424,940	23,152	433,217
1888	2,643	30,247	16,133	268,362	18,776	298,609
1889	3,547	38,833	26,440	355,935	29,987	394,768
1890	1,866	21,329	26,591	478,040	28,457	499,369
1891	1,551	16,646	15,720	368,015	17,271	384,661
1892	1,501	12,544	9,981	141,221	11,482	153,765
1893	1,990	11,550	5,748	56,402	7,738	67,952
1894	1,980	10,560	3,470	29,610	5,450	40,170
1895	.....	.....	250	2,500	250	2,500
1896	1	5	299	2,990	300	2,995
1897	70	450	165	400	235	850
1898	21	240	702	8,000	723	8,240
1899	215	1,850	93	1,725	308	3,575

*These values do not compare with those in Table 1 above, the spot value being adopted for the production whilst the exports are valued upon quite a different basis.

PRECIOUS METALS.

The precious metals, gold and silver, are considered together, following the custom of past years.

Gold.

Owing largely to the continued productiveness of the Yukon placer deposits, the yield of gold in Canada in 1899 reached a total value of $21,261,584, a value which the yearly total mineral production of Canada previous to 1895 had not attained.

In 1898 the output was $13,775,420, so that the increase in 1899 amounted to $7,486,164 or 54 per cent. The increase of 1898 over 1897 was 128 per cent, and of 1897 over 1896 118 per cent.

As has been said, much of these large increases is due to the placer workings on the rivers of the Yukon district, nevertheless while attention is thus drawn to our present chief source of supply, due credit must at the same time be given to our other gold areas whose output has been steadily increasing. Excluding the product of the Yukon, the increase in the output of the other gold fields in 1899 over 1898 amounted to 39·3 per cent, the increase of 1898 over 1897 being 7 per cent, and of 1897 over 1896, 43·6 per cent.

The proportions contributed by the various provinces to the total in 1899, were approximately as follows: Yukon district 75 per cent, British Columbia, nearly 20 per cent, Nova Scotia about 3 per cent. and Ontario about 2 per cent. $17,364,816 or nearly 82 per cent. of the total was derived from placer workings and $3,896,768 or 18 per cent. from milling and smelting ores.

Increases in production are shown in all the important gold producing provinces, viz. Nova Scotia, Ontario, British Columbia and the Yukon district, those in which decreases are shown, Quebec and the Saskatchewan River, having but a small output compared with the others.

The production of gold in Canada since 1887 is shown in Table 1, while that by provinces in 1899 is exhibited in Table 2. Table F illustrates graphically, the variations in the output of the provinces and of the Dominion as a whole.

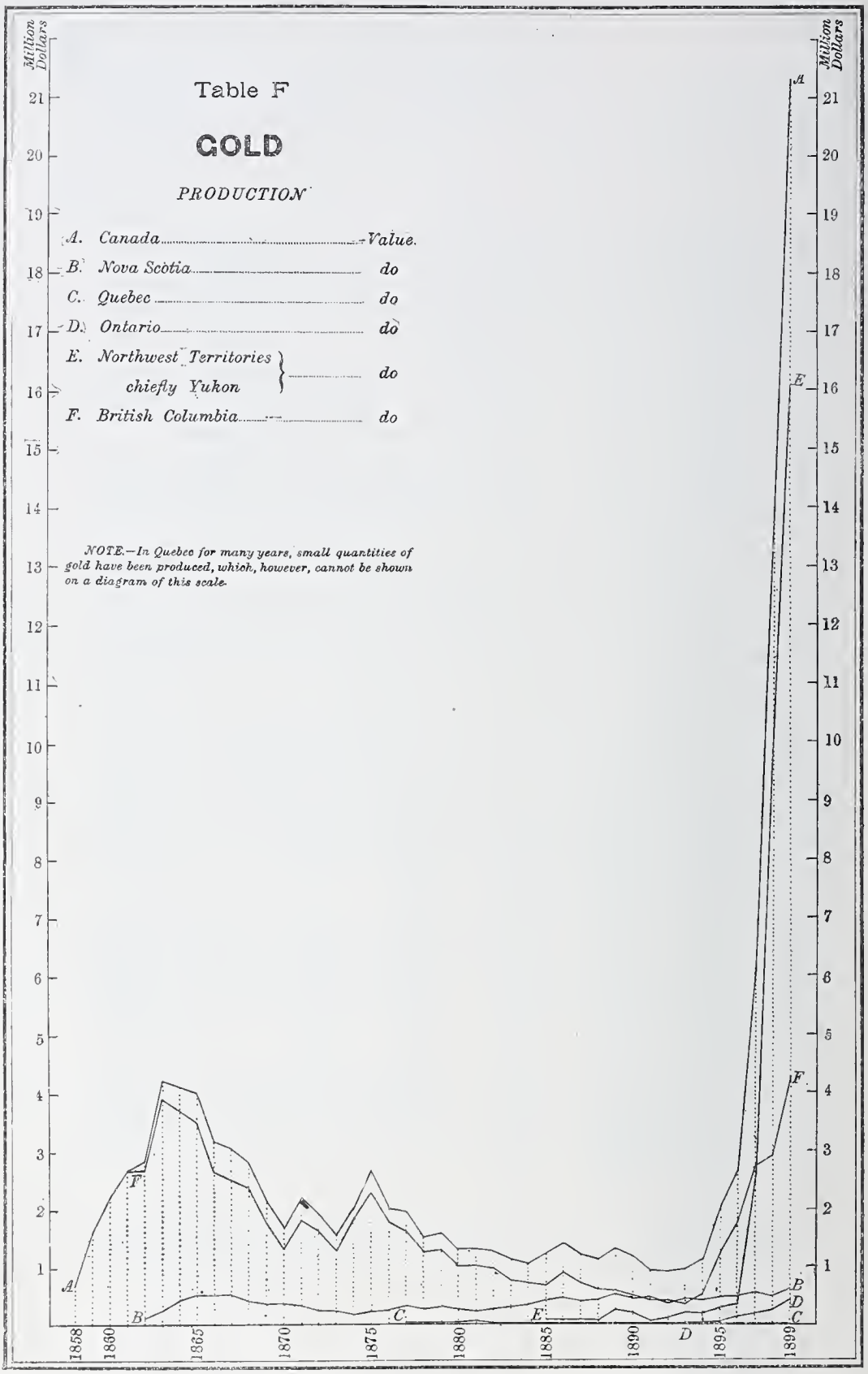


Table F
GOLD
PRODUCTION
A. Canada ..... Value.
B. Nova Scotia ..... do
C. Quebec ..... do
D. Ontario ..... do
E. Northwest Territories chiefly Yukon ..... do
F. British Columbia ..... do
NOTE.—In Quebec for many years, small quantities of gold have been produced, which, however, cannot be shown on a diagram of this scale.
Million Dollars
1858
1860
1865
1870
1875
1880
1885
1890
1895
1899

Table 1.
Precious Metals.
Gold—Annual Production in Canada.

Precious Metals.

Gold.

Production.

Calendar Year.	*Ounces. Fine.	Value.
1887	57,465	$ 1,187,804
1888	53,150	1,098,610
1889	62,658	1,295,159
1890	55,625	1,149,776
1891	45,022	930,614
1892	43,909	907,601
1893	47,247	976,603
1894	54,605	1,128,688
1895	100,806	2,083,674
1896	133,274	2,754,774
1897	291,582	6,027,016
1898	666,445	13,775,420
1899	1,028,620	21,261,584

* Calculated from the values at the rate of $20.67 per ounce.

Table 2.
Precious Metals.
Gold: Production by Provinces and Districts, Calendar Year 1899.

Province.	*Ounces. Fine.	Value.
Nova Scotia	(b) 29,879	$ 617,604
Quebec	(a) 238	4,916
Ontario	(b) 20,395	421,591
North-west Territories—		
Yukon District	(a) 774,069	16,000,000
Saskatchewan River	(a) 726	15,000
British Columbia	(c) 203,313	4,202,473
Total	1,028,620	$21,261,584

*Calculated from the values at the rate of $20 67 per ounce.
(a) Placer gold.
(b) Gold produced in treating free milling ores.
(c) As follows: Gold from placer mining $1,344,900
" " vein " 2,857,573
$4,202,473

Nova Scotia.

Nova Scotia.

The statistics of gold production in Nova Scotia are given in Tables 3, 4, 5 and 6. Table 3 shows the annual gold output. Table 4, the tons of quartz crushed and the average yield per ton.

In Table 5, the total product of each district from 1862 to the end of 1899 is exhibited as well as the average yield per ton, and Table 6 shows the amount of ore crushed and the yield per district for 1899.

Precious Metals.

Gold.

Nova Scotia.

The production in 1899 $617,604 is the highest recorded and is greater than that of the previous year by $79,014 or nearly 15 per cent. The quantity of quartz crushed increased in even greater proportion than the output of gold, so that the average yield per ton was only $5.50 as compared with $6.50 in 1898. An examination of Table 4 will show that from 1862 to 1892 the average yield per ton, varied from $22 to $11, while since 1892, the yield has averaged less than $8 per ton.

In Table 6, the production of 28 different districts is shown, there being 68 mines and 55 mills represented. In 1898 there were but 54 mines and 43 mills represented as producing. Three districts, Stormont, Sherbrooke and Brookfield, are credited with over 54 per cent. of the total output, while four districts, Caribou, Oldham, Salmon River and Wine Harbour, producing over 1,000 ounces each, account for another 21 per cent.

The highest average yield per ton, from districts producing over 1,000 ounces, was from Wine Harbour, the return there being 18 dwt. 12 grs. or $18.03 and the least was from Salmon River with an average of 1 dwt. 18 grs. or $1.71 per ton. The greatest yield of any district was obtained from Renfrew with a return of 3 oz. 16 dwt. 21 grs. or $74.95 per ton. The average yield for the province was 5 dwt. 15 grs. or $5.50.

Table 3.

Precious Metals.

Production.

Gold:—Nova Scotia—Annual Production.

Calendar Year.	Value.	Calendar Year.	Value.
1862	$141,871	1881	$209,755
1863	272,448	1882	275,090
1864	390,349	1883	301,207
1865	496,357	1884	313,554
1866	491,491	1885	432,971
1867	532,563	1886	455,564
1868	400,555	1887	413,631
1869	348,427	1888	436,939
1870	387,392	1889	510,029
1871	374,972	1890	474,990
1872	255,349	1891	451,503
1873	231,122	1892	389,965
1874	178,244	1893	381,095
1875	218,629	1894	389,338
1876	233,585	1895	453,119
1877	329,205	1896	493,568
1878	245,253	1897	562,165
1879	268,328	1898	538,590
1880	257,823	1899	617,604

Table 4.
Precious Metals.
Gold:—Nova Scotia, Ore Treated and Yield of Gold per Ton.

Precious Metals. Gold. Nova Scotia.

Calendar Year.	Tons Treated.	Yield of Gold per Ton.	Calendar Year.	Tons Treated.	Yield of Gold per Ton.
1862	6,473	$21·91	1881	16,556	$12·66
1863	17,000	16·02	1882	21,081	13·04
1864	21,431	18·21	1883	25,954	11·60
1865	24,421	20·32	1884	25,186	12·44
1866	32,157	15·28	1885	28,890	14·98
1867	31,384	16·96	1886	29,010	15·70
1868	32,259	12·41	1887	32,280	12·81
1869	35,144	19·91	1888	36,178	12·08
1870	30,824	12·56	1889	39,160	13·02
1871	30,787	12·17	1890	42,749	11·11
1872	17,089	14·94	1891	36,351	12·42
1873	17,708	13·05	1892	32,552	11 98
1874	13,844	12·87	1893	42,354	8·99
1875	14,810	14·76	1894	55,357	7·04
1876	15,490	15·08	1895	60,600	7·47
1877	17,369	18·95	1896	69,169	7·13
1878	17,989	13·63	1897	73,192	7·68
1879	15,936	16·83	1898	82,774	6·50
1880	13,997	18·42	1899	112,226	5.50

Table 5.
Precious Metals.
Gold:—Nova Scotia.—Production of the Different Districts from 1862 to 1899 inclusive.

Production.

Districts.	Tons of Ore Crushed.	Total Yield.				Average Yield per Ton of 2,000 lbs.
		Ozs.	Dwts.	Grs.	Value at $19.50 per Oz.	
					$	$ cts.
Brookfield	43,955	22,123	13	9	431,411	9.81
Caribou	121,691	41,744	2	11	814,010	6.69
Central Rawdon	13,340	10,121	11	21	197,371	14.80
Fifteen-mile Stream	40,280	18,132	13	5	353,587	8.78
Killag	1,291	1,967	8	12	38,365	29.72
Lake Catcha	14,330	12,384		5	241,488	16.85
Malaga	24,129	16,790	19	21	327,425	13.57
Montague	24,968	39,290	1	5	766,156	30.68
Oldham	47,805	51,932	12	20	1,012,687	21.18
Renfrew	48,707	34,525	17	2	673,254	13.82
Salmon River	99,277	33,303	2	21	649,411	6.54
Sherbrooke	230,081	141,026	9	1	2,750,016	11.95
Stormont	185,003	67,031	7	11	1,307,112	7.07
Tangier	37,181	22,020	2	2	429,392	11.55
Uniacke	56,384	38,840	16	8	757,396	13.43
Waverly	122,832	61,761	14	21	1,204,354	9.80
Wine Harbour	47,358	32,349	9	18	630,815	13.32
Whiteburn	7,378	10,218	18	20	199,269	27.01
Other Districts	69,189	50,317	1	11	981,183	14.18
Totals	1,235,179	705,882	3	8	13,764,702	11.14

Precious Metals.

Table 6.

Precious Metals.

Gold.

Gold :—Nova Scotia, District Details—Calendar Year 1899.

Nova Scotia.

Districts.	Mines.	Mills.	Tons of Ore Crushed.	Total Yield of Gold.			Average Yield of Gold per Ton.		
				Ozs.	Dwt.	Grs.	Oz.	Dwt.	Grs.
Blockhouse	2	1	564	980	..	..	1	14	17
Brookfield	2	2	10,117	3,239	1	5	..	6	9
Caribou	7	7	14,231	1,509	12	6	..	2	3
Carleton	1	1	12	15	..	..	1	5	..
Cow Bay	2	1	52	41	13	10	..	16	..
Cranberry Head	1	1	56	38	14	..	..	13	11
East Rawdon	1	1	20	2	8	6	..	2	10
Gold River	2	1	67	17	8	22	..	5	5
Harrigan Cove	1	1	720	498	13	12	..	13	20
Kemptville	1	1	138	70	17	..	..	1	6
Killag	2	1	264	439	12	..	1	13	..
Lake Catcha	4	3	1,093	792	12	22	..	14	12
Lawrencetown	1	1	110	69	7	9	..	12	14
Leipsigate	3	2	2,818	937	12	..	..	6	15
Liscomb Mills	1	..	13	....	10	8	..	..	18
Malaga Barrens	1	1	306	184	15	..	..	12	1
Montague	2	3	1,517	931	9	19	..	12	6
Oldham	4	1	2.254	1,527	8	..	.	13	13
Renfrew	3	1	131	503	16	..	3	16	21
Salmon River	1	1	15,249	1,336	4	2	..	1	18
Sherbrooke	4	4	18,367	4,879	19	15	..	5	8
Shiers Point	1	1	573	94	8	15	..	3	7
Stormont	10	11	35,398	9,122	12	12	..	5	3
Tangier	2	1	1,438	625	..	..	..	8	16
Uniacke	4	3	1,309	649	18	..	..	9	22
Waverly	1	1	2,878	822	14	2	..	5	17
Whiteburn	1	1	10	5	..	..	..	10	..
Wine Harbour	3	2	2,521	2,335	18	12	..	18	12
Totals and averages	68	55	112,226	31,672	7	9	..	5	15

Quebec.

Quebec.

In this province work has been continued by the Gilbert Beauce Gold Mining Company and the Compagnie Franco-Canadienne on the Gilbert River, in the Chaudière district, but only mediocre success has attended their efforts.

Statistics of production are shown in Table 7.

Table 7.
Precious Metals.
Gold:—Quebec, Annual Production.

Precious Metals.

Gold.

Quebec.

Calendar Year.	Value.	Calendar Year.	Value.
1877	$12,057	1889	$1,207
1878	17,937	1890	1,350
1879	23,972	1891	1,800
1880	33,174	1892	12,987
1881	56,661	1893	15,696
1882	17,093	1894	29,196
1883	17,787	1895	1,281
1884	8,720	1896	3,000
1885	2,120	1897	900
1886	3,981	1898	6,089
1887	1,604	1899	4,916
1888	3,740		

Ontario.

Ontario

Most of the gold output from Ontario is derived from the free milling ore of the western part of the province though the gold found in association with arsenical pyrites in Hastings county is worked to a considerable extent. The gold industry has been of comparatively recent growth, amounting in 1891 to only $2,000. The output for 1899 was $421,591, as compared with $265,889 in 1898, the increase being $155,702, or 58 per cent.

From 65,403 tons of ore mined there was obtained 25,371 ounces of crude bullion, of an average value per ounce of $16.62. The value per ton of ore treated ranged from $3.56 to $11 and averaged $6.45 for the total output.

Table 8.
Precious Metals.
Gold—Ontario—Annual Production.

Calendar Year.	*Ounces (fine).	Value.
		$
1887	327	6,760
1888		
1889		
1890		
1891	97	2,000
1892	344	7,118
1893	708	14,637
1894	1,917	39,624
1895	3,015	62,320
1896	5,563	115,000
1897	9,158	189,294
1898	12,864	265,889
1899	20,395	421,591

* Calculated from the value at the rate of $20·67 per ounce.

Precious Metals.

Gold.

The greater part of the production came from six mines, the Regina, Sultana, Mikado and Golden Star, in western Ontario, and the Deloro and Belmont, in Hastings county.

Ontario.

The Canadian Gold Fields Ltd., which operated the Deloro Mine, have replaced their buildings and machinery which were destroyed by fire in 1898. The ore is an arsenical pyrites, carrying gold, and the company is now recovering the arsenic as well as the gold.

The Boerth Mining Company have opened up the Boerth Mine in Clarendon township, Frontenac county. A ten stamp mill has been erected. The property is well equipped with necessary buildings and mining machinery, and satisfactory results are reported.

North-west Territories.

North-west Territories.

The gold-fields of the North-west Territories are confined to the alluvial workings of the Saskatchewan River, and those of the Yukon River and its tributaries. The difficulty of obtaining anything like accurate statistics of the output from such deposits as these, where thousand of men are independently engaged in mining the precious metal, will be easily recognized. Much of the Saskatchewan River gold finds its way to the local banks, and a basis for an estimation of the product is thus found, while the greater part of the Yukon gold is ultimately sold at the different receiving offices of the United States mint. The receipts of these offices, taken in conjunction with careful estimates by government officers, bank managers, and transportation companies at Dawson, furnish a means of estimating the Yukon output, probably as accurately as it is possible to obtain it.

Statistics of production in the two districts since 1887 are shown in Table 9.

TABLE 9.

PRECIOUS METALS.

GOLD—NORTH-WEST TERRITORIES—PRODUCTION.

Calendar Year.	Yukon District.		Saskatchewan River.	
	*Ounces (fine).	Value.	*Ounces (fine).	Value.
		$		$
1885 } 1886 }	4,838	100,000	.....	.....
1887	3,387	70,000	102	2,100
1888	1,935	40,000	58	1,200
1889	8,466	175,000	968	20,000
1890	8,466	175,000	194	4,000
1891	1,935	40,000	266	5,500
1892	4,233	87,500	508	10,506
1893	8,515	176,000	466	9,640
1894	6,047	125,000	725	15,000
1895	12,095	250,000	2,419	50,000
1896	14,514	300,000	2,661	55,000
1897	120,948	2,500,000	2,419	50,000
1898	483,793	10,000,000	1,209	25,000
1899	774,069	16,000,000	726	15,000
Total	1,453,241	30,038,500	12,721	262,946

*Calculated from the value at $20.67 per ounce.

The production of the Yukon District in 1899 is estimated at $16,000,000 an increase over the previous year of $6,000,000 or 60 per cent. The total output of this district to the end of 1899, has been over $30,000,000.

The occurrence of gold and the geological features of the district, are being examined by Mr. R. G. McConnell of the survey, and a full preliminary report of his investigations during the summer of 1899, will be found in the Summary Report for that year.

Mr. McConnell reports 'It is unlikely that the rapid increase in production of the last two years will be continued, as serious inroads have already been made on the rich portions of Eldorado and Bonanza creeks, and to a less extent on Hunker and Dominion creeks, but the amounts remaining, with the long stretches of medium and low grade gravels still untouched on all the creeks, ensure a high production for a number of years.'

'The employment of machinery in the working of Klondyke claims is gradually increasing, but is still insignificant, a fact due largely to the absence of roads and the consequent impossibility of transporting heavy pieces up the creeks. Steam thawers are largely used and

Precious Metals.

Gold.

steam pumps are gradually replacing hand pumps, Chinese pumps and water-wheels for draining the pits. Steam-hoists are employed at a few of the mines, but are not in general use.

North-west Territories.

'The greater part of the work of the camp is still done by hand, and this notwithstanding the fact that, taking into consideration the high price of labour, nowhere in the world could machinery be more profitably employed.'

'Very little work was done during the past season in the Yukon district, outside the Klondyke gold fields. The Stewart River was further prospected by a few parties and reports of strikes on some of the tributaries were current, but it was impossible to learn anything definite about them. A strike is also reported farther to the north on a couple of tributaries of the South fork of the Salmon, and a small quantity of coarse high grade gold purporting to come from there, was seen by the writer when on the way out. The creeks at the head of Sixty-mile River, which was almost abandoned after the Klondike discoveries, are also again beginning to attract some attention.'

British Columbia.

British Columbia.

The record production of gold in British Columbia, which was made in 1863, and amounted to $3,913,563 has at last been exceeded. The output for 1899 was $4,202, 473 and was greater than the output for 1898 by nearly 13 per cent. The production of 1863 and for many years subsequently was derived entirely from placer workings, whereas during the past year 32 per cent. of the product was obtained from the placer and hydraulic workings and 68 per cent. from lode mining.

Statistics of production since 1858 are shown in Table 10 while the production for 1899, by districts, is shown in Table 11.

Placer Mining.—The yield of placer gold was $1,344,900, an amount not equalled within the past twelve years, and over double the placer yield for 1898. This increase is due to the Atlin District, in the northern part of the province, the output of which is reported as $800,000. The output of the other placer districts has not changed much from the previous year.

Work has been continued on a number of important hydraulicking enterprises in the Caribou District. The output of gold from these however has not been materially increased.

TABLE 10.
PRECIOUS METALS.
GOLD:—BRITISH COLUMBIA—ANNUAL PRODUCTION.

Calendar Year.	Value.	Calendar Year.	Value.
	$		$
1858	705,000	1879	1,290,058
1859	1,615,072	1880	1,013,827
1860	2,228,543	1881	1,046,737
1861	2,666,118	1882	954,085
1862	2,656,903	1883	794,252
1863	3,913,563	1884	736,165
1864	3,735,850	1885	713,738
1865	3,491,205	1886	903,651
1866	2,662,106	1887	693,709
1867	2,480,868	1888	616,731
1868	2,372,972	1889	588,923
1869	1,774,978	1890	494,436
1870	1,336,956	1891	429,811
1871	1,799,440	1892	399,525
1872	1,610,972	1893	379,535
1873	1,305,749	1894	530,530
1874	1,844,618	1895	1,266,954
1875	2,474,904	1896	1,788,206
1876	1,786,648	1897	2,724,657
1877	1,608,182	1898	2,939,852
1878	1,275,204	1899	4,202,473

TABLE 11.
PRECIOUS METALS.
GOLD:—BRITISH COLUMBIA—PRODUCTION BY DISTRICTS.

DISTRICTS.	GOLD, PLACER.		GOLD, LODE.	
	Ounces.	Value.	Ounces.	Value.
		$		$
Cariboo:				
Richfield Division	9,000	180,000		
Quesnel "	9,665	193,300		
Omineca "	430	8,600		
Cassiar:				
Atlin Lake Division	40,000	800,000		
All other	969	19,380		
East Kootenay:				
Fort Steele Division	500	10,000		
West Kootenay:				
Ainsworth Division			91	1,888
Nelson "			16,569	342,308
Slocan "			14	284
Trail Creek "			102,976	2,127,482
All other "	300	6,000	118	2,439
Lillooet	2,135	42,700	1,300	26,858
Yale:				
Osoyoos Division	180	3,600	11,086	229,028
Similkameen "	330	6,600		
Yale "	3,736	74,720	2	45
Coast and other Districts			6,159	127,241
Total	67,245	1,344,900	138,315	2,857,573

Precious Metals.

Gold.

Lode Mining.—As usual the Rossland Camp contributed the greater part of the output of gold from lode mining, over 74 per cent, and this chiefly from the LeRoi, War Eagle, and Centre Star mines.

British Columbia.

The Nelson Division of West Kootenay, contributed about 12 per cent, derived largely from the operation of the Ymir mines. The Osoyoos Division of Yale accounted for about 8 per cent. of the total, being almost all the product of the Cariboo and other claims, owned by the Cariboo McKinney Gold Mining and Milling Co., Ltd.

The following tables compiled from the Reports of the Minister of Mines for British Columbia, show the production of the Rossland mines, and illustrate the average results attained during the past six years.

Net Production, per Smelter Returns.

Year.	Ore, tons, 2,000 lbs.	Gold, oz.	Silver, oz.	Copper, lbs.	Value.
1894	1,856	3,723	5,357	106,229	$ 75,510
1895	19,693	31,497	46,762	840,420	702,459
1896	38,075	55,275	89,285	1,580,635	1,243,360
1897	68,804	97,024	110,068	1,819,586	2,097,280
1898	111,282	87,343	170,804	5,232,011	2,470,811
1899	172,665	102,976	185,818	5,693,889	3,229,086
Total	412,375	377,838	608,034	15,272,770	9,818,506

Average Net Smelter Returns, or Actual Yield per Ton.

Year.	Gold.	Silver.	Copper.	Value.
	Ounces.	Ounces.	%	$
1894	2·00	2·89	2·85	40·69
1895	1·60	2·41	2·10	35·67
1896	1·45	2·34	2·08	32·65
1897	1 42	1·60	1·32	30·48
1898	·78	1·54	2·35	22·10
1899	·596	1·07	1·65	18·70
Average 412.375 tons	·916	1·47	1·85	23·81

Silver.

Silver.

The production of silver in Canada reached a maximum in 1897, when the output was 5,558,446 ounces valued at $3,323,395. The past two years have shown successive decreases, so that the output of 1899 which was 3,411,644 ounces valued at $2,032,658 or 59·58 cents per ounce, was less than the output of 1897 by over a million dollars.

The statistics of production of silver since 1887, are shown in Table 12 below, and the variations are exhibited graphically in Table G.

Table 12.

Precious Metals.

Silver :—Annual Production.

Calendar Year.	Ontario.		Quebec.		British Columbia.		Total.	
	Ounces.	Value.	Ounces.	Value.	Ounces.	Value.	Ounces.	Value.
1887..	190,495	$186,304	146,898	$143,666	17,690	$17,301	355,083	$347,271
1888..	208,064	195,580	149,388	140,425	79,780	74,993	437,232	410,998
1889..	181,609	169,986	148,517	139,012	53,192	49,787	383,318	358,785
1890..	158,715	166,016	171,545	179,436	70,427	73,666	400,687	419,118
1891..	225,633	222,926	185,584	183,357	3,306	3,266	414,523	409,549
1892..	41,581	36,425	191,910	168,113	77,160	67,592	310,651	272,130
1893..	.....	8,689	.....	126,439	.....	195,000	.....	330,128
1894..	.....	.....	101,318	63,830	746,379	470,219	847,697	534,049
1895 .	.....	.....	81,753	53,369	1,496,522	976,930	1,578,275	1,030,299
1896..	.... ..	.....	70,000	46,942	3,135,343	2,102,561	3,205,343	2,149,503
1897..	5,000	2,990	80,475	48,116	5,472,971	3,272,289	5,558,446	3,323,395
1898..	85,000	49,521	74,932	43,655	4,292,401	2,500,753	4,452,333	2,593,929

		Ounces.	Value.
1899	Quebec.....	40,231	$ 23,970
	Ontario.....	202,000	120,352
	Yukon district.....	230,000	137,034
	British Columbia.....	2,939,413	1,751,302
	Total.....	3,411,644	2,032,658

The production of silver has increased very largely since 1894 due, as will be seen from the table, entirely to the output from British Columbia. The other provinces, Ontario and Quebec were, previous to 1894, the most important silver producers, British Columbia in these years occupying but a secondary position. Since 1894, however, production in the eastern provinces has greatly fallen away, ceasing altogether in Ontario in 1894, 1895 and 1896, while in Quebec the output is not much more than one fourth of what it was ten years ago.

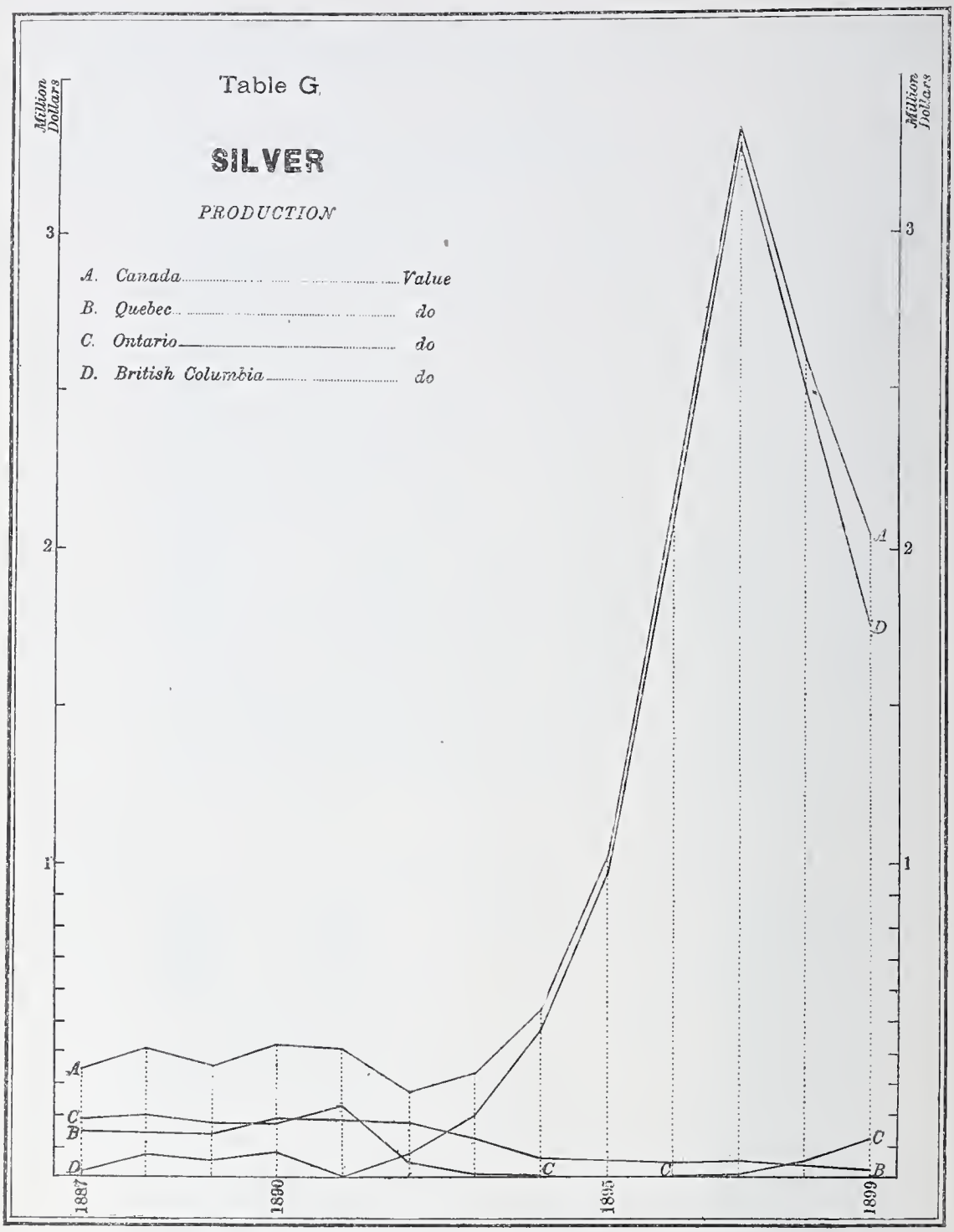


Table G
SILVER
PRODUCTION
A. Canada ..... Value
B. Quebec ..... do
C. Ontario ..... do
D. British Columbia ..... do
Million Dollars
Million Dollars
3
2
1
1887
1890
1895
1899
A
B
C
D

During the past three years there has been a small revival of interest in Ontario, the West End Mines Syndicate having reopened a number of mines in the Thunder Bay district. PRECIOUS METALS. Silver.

In Quebec the silver is as usual derived from the pyrites deposits in the vicinity of Capelton, in the Eastern Townships. The pyrites is mined primarily as a source of sulphur for acid making, but the silver is saved as a by-product.

BRITISH COLUMBIA. British Columbia.

The silver production in British Columbia, is chiefly from the silver-lead ores of the Slocan, the silver-copper ores of Nelson, the pyrrhotite and chalcopyrite ores of Rossland also contributing to the total output.

The production by districts in 1898 and 1899 was as follows : — Production.

District.	1898.	1899.
	Oz.	Oz.
Kootenay East—		
Fort Steele Division	69,780	33,516
Other Divisions	.....	1,627
Kootenay West—		
Ainsworth Division	167,147	268,165
Nelson "	692,367	483,659
Slocan "	3,068,648	1,891,025
Trail Creek "	170,804	185,818
Other "	121,510	48,463
Yale—Osoyoos Division	.....	2,719
Similkameen	.....	16
Yale	.....	47
Coast and other districts	2,145	24,358
Total	4,292,401	2,939,413

The most important change is the large decrease in the output of the Slocan. In this division in 1899, 21,507 tons of ore were mined as compared with 30,691 tons in 1898 and 33,567 tons in 1897. The labour troubles of 1899 doubtless had much to do with this decrease.

The following tables show the output, and average yield per ton of the Slocan mines for the past five years.

NET PRODUCTION PER SMELTER RETURNS.

Year.	Ore, Tons, 2,000 lbs.	Silver, oz.	Lead, lbs.	Gold, oz.	Values.
1895	9,514	1,122,770	9,666,324	6	$1,045,600
1896	16,560	1,954,258	18,175,074	152	1,854,011
1897	33,567	3,641,287	30,707,705	193	3,280,686
1898	30,691	3,068,648	27,063,595	60	2,619,852
1899	21,507	1,891,025	16,660,910	14	1,740,372
Totals	111,839	11,677,988	102,273,608	425	$10,540,521

Precious Metals.

Silver.

British Columbia.

Actual Yield per Ton.

Year.	Silver.	Lead.	Value.
1895	118·0 oz.	50·8%	$109 90
1896	118·0 "	54·9%	111 95
1897	108·5 "	45·7%	97 73
1898	100·0 "	44·1%	85 36
1899	87·9 "	38·7%	80 92
For 111,839 tons	104·4	45·7%	94 25

The following Table, No. 13, gives the exports of silver ores as entered in the customs returns. Attention should perhaps be drawn to the discrepancies between this and Table 12, the table of production, since it would appear to show that more silver has been exported than has been produced during the past four years. The figures of production for these years are known to be based upon smelter returns and the quantities are valued at the average market value for the refined metal ; they can therefore be assumed to be the more correct.

Table 13.

Precious Metals.

Exports.

Silver :—Exports of Ore.*

Province.	Calendar Year.						
	1893.	1894.	1895.	1896.	1897.	1898.	1899.
	$	$	$	$	$	$	$
Ontario	7,878	.....	100	.....	5,885	40,298	61,948
Manitoba	820	.....	.....	.....	.....	.....	.....
N.-W. Territories	.....	.....	.....	.....	.....	1,212	7,743
British Columbia	204,997	359,731	994,254	2,271,959	3,570,506	2,860,767	1,554,214
Totals	213,695	359,731	994,354	2,271,959	3,576,391	2,902,277	1,623,905

* The production of silver given under the heading Quebec, in Table 12, represents the amount of that metal in the pyritous copper ores produced and exported from that province. Being but in small proportion, it is ignored, and does not appear under the heading silver in the export returns.

PYRITES.

The mines of the Eustis Mining Co. and the Nichols Chemical Co. in the Eastern Townships, province of Quebec, continue to be the source of production of pyrites, statistics of which are given in Table 1 below. The mines are situated in the township of Ascot, in the vicinity of Capelton. The ore, which consists mainly of the sulphides of iron and copper, carries about 42 per cent of sulphur, from 3 to 4 per cent of copper and from 2 to 4 ounces of silver per ton. Although mined primarily for use in the manufacture of sulphuric acid, both the copper and silver are extracted with some profit. A small proportion is used in Canada for making sulphuric acid; but the bulk of the ore is shipped to the manufacturing establishments of the Nichols Company, and to other plants in the United States.

Table 1.

Pyrites.

Annual Production.

Production.

Calendar Year.	Tons. 2,000 lbs.	Value.
		$
1886	42,906	193,077
1887	38,043	171,194
1888	63,479	285,656
1889	72,225	307,292
1890	49,227	123,067
1891	67,731	203,193
1892	59,770	179,310
1893	58,542	175,626
1894	40,527	121,581
1895	34,198	102,594
1896	33,715	101,155
1897	38,910	116,730
1898	32,218	128,872
1899	27,687	110,748

Pyrites.

Imports.

Table 2.

Pyrites.

Imports.—Brimstone and Crude Sulphur.

Fiscal Year.	Pounds.	Value.
1880	1,775,489	$27,401
1881	2,118,720	33,956
1882	2,375,821	40,329
1883	2,336,085	36,737
1884	2,195,735	37,463
1885	2,248,986	35,043
1886	2,922,043	43,651
1887	3,103,644	38,750
1888	2,048,812	25,318
1889	2,427,510	34,006
1890	4,440,799	44,276
1891	3,601,748	46,351
1892	4,769,759	67,095
1893	6,381,203	77,216
1894	5,845,463	61,558
1895	4,900,225	56,965
1896	6,934,190	63,973
1897	8,672,751	87,719
1898	38,026,798	373,786
1899*	24,517,026	265,799

*Brimstone, crude, or in roll or flour, and sulphur crude in roll or flour. Duty free.

Salt.

SALT.

The production of salt in 1899 amounted to 59,339 tons valued at $254,390 or an average of $4.28 per ton being an increase over the previous year of 2,197 tons or 3·8 per cent in quantity and $5,751 or 2·3 per cent in value.

This is entirely the output of the Ontario salt fields, returns having been received from some twelve operators.

Small quantities of salt are occasionally produced at the Sussex salt works in New Brunswick, and at Lake Winnipegosis, Man., but these were not operated during 1899.

There is a considerable amount of salt imported for use in the sea and gulf fisheries, but otherwise the imports of salt entering into direct competition with the Canadian product are of comparatively small amount. The value of these in 1899 was $32,792 or less than 13 per cent. of the home output.

TABLE 1.

SALT.

PRODUCTION.

Calendar Year.	Tons.	Value.
1886	62,359	$227,195
1887	60,173	166,394
1888	59,070	185,460
1889	32,832	129,547
1890	43,754	198,857
1891	45,021	161,179
1892	45,486	162,041
1893	62,324	195,926
1894	57,199	170,687
1895	52,376	160,455
1896	43,960	169,693
1897	51,348	225,730
1898	57,142	248,639
1899	59,339	254,390

TABLE 2.

SALT.

EXPORTS.

Calendar Year.	Bushels.	Value.
1880	467,641	$46,211
1881	343,208	44,627
1882	181,758	18,350
1883	199,733	19,492
1884	167,029	15,291
1885	246,794	18,756
1886	224,943	16,886
1887	154,045	11,526
1888	15,251	3,987
1889	8,557	2,390
1890	6,605	1,667
1891	5,290	1,277
1892	2,000	504
1893	4,940	1,267
1894	4,639	1,120
1895	4,865	959
1896	3,842	899
1897	5,383	1,193
1898	5,202	1,252
1899	11,205	2,773

Salt.

Imports.

Table 3.

Salt.

Imports—Salt Paying Duty.

Fiscal Year.	Pounds.	Value.	Fiscal Year.	Pounds.	Value.
1880	726,640	$ 3,916	1890	15,135,109	$57,549
1881	2,588,465	6,355	1891	15,140,827	59,311
1882	3,679,415	12,318	1892	18,648,191	65,963
1883	12,136,968	36,223	1893	21,377,339	79,838
1884	12,770,950	38,949	1894	15,867,825	53,336
1885	10,397,761	31,726	1895	8,498,404	29,881
1886	12,266,021	39,181	1896	7,665,257	24,550
1887	10,413.258	35,670	1897	11,911,766	33,470
1888	10,509,799	32,136	1898	11,068,785	32,792
1889	11,190,088	38,968			

		Duty.		
1899	Salt, coarse, N.E.S.	5c. per 100 lbs.	5,659,390	11,917
	Salt, fine, in bulk	5c. "	1,707,050	3,000
	Salt, N.E.S., in bags, barrels or other packages	7½c. "	4,415,013	17,922
	Total		11,781,453	32,839

Table 4.

Salt.

Imports—Salt not Paying Duty.

Fiscal Year.	Pounds.	Value.
1880	212,714,747	$400,167
1881	231,640,610	488,278
1882	166,183,962	311,489
1883	246,747,113	386,144
1884	225,390,121	321,243
1885	171,571,209	255,719
1886	180,205,949	255,359
1887	203,042,332	285,455
1888	184,166,986	220,975
1889	180,847,800	253,009
1890	158,490,075	252,291
1891	195,491,410	321,239
1892	201,831,217	314,995
1893	191,595,530	281,462
1894	196,668,730	328,300
1895	201,691,248	332,711
1896	205,005,100	338,888
1897	215,844,484	312,117
1898	202,634,927	293,410
1899*	183,046,365	267,520

*Salt, imported from the United Kingdom, or any British possession, or imported for the use of the sea or gulf fisheries.

STRUCTURAL MATERIALS.

Structural Materials.

Under this heading are comprised building stone, granites, marbles, slates, flagstones, cements, lime, etc., as well as the manufactures of clay, which include building bricks, tiles, drain-pipe, earthenware and coarse pottery.

The industries based on the stuctural materials are so widespread and are carried on in so many different places, on various scales and often intermittently, that it is impossible to obtain anything like complete returns of quantity or value of the products. The figures of production are therefore to be taken only as rough approximations.

Table 1.
Structural Materials.
Production of Building Stone.

Building Stone.

Calendar Year.	Value.
1886	$ 642,509
1887	552,267
1888	641,712
1889	913,691
1890	964,783
1891	708,736
1892	609,827
1893	1,100,000
1894	1,200,000
1895	1,095,000
1896	1,000,000
1897	1,000,000
1898	1,300,000
1899	1,500,000

Table 2.
Structural Materials.
Exports of Stone and Marble, Wrought and Unwrought.

Stone and Marble.

Province.	Wrought.		Unwrought.	
	Calendar Years.			
	1898.	1899.	1898.	1899.
Ontario	$379	$4,495	$63,755	$96,976
Quebec	708	170	...	4
Nova Scotia	932	248	885	4,494
New Brunswick	507	169	730	273
British Columbia	.....	10	.....	184
Totals	$2,526	$5,092	$65,370	$101,931

Structural Materials.

Building Stone.

Table 3.

Structural Materials.

Imports of Building Stone.

Fiscal Year.	Value.	Fiscal Year.	Value.
1880	$ 35,970	1890	$ 132,155
1881	58,149	1891	170,890
1882	33,623	1892	95,550
1883	35,061	1893	56,510
1884	51,088	1894	52,908
1885	30,491	1895	44,282
1886	41,675	1896	54,130
1887	54,368	1897	38,714
1888	86,373	1898	28,495
1889	100,314		
1899 — Flagstones, granite and rough freestone, sandstone, and all building stone, not hammered or chiselled. Duty 15 p.c.			$43,494
1899 — Granite and freestones, dressed; all other building stone dressed, except marble. Duty 20 p.c.			4,546
			$48,040

Table 4.

Structural Materials.

Imports of Manufactures of Stone or Granite, N.E.S.

Fiscal Year.	Value.	Fiscal Year.	Value.
1880	$29,408	1890	$84,396
1881	36,877	1891	61,051
1882	37,267	1892	39,479
1883	45,636	1893	49,323
1884	45,290	1894	49,510
1885	39,867	1895	51,050
1886	41,984	1896	51,499
1887	41,829	1897	34,026
1888	47,487	1898	41,240
1889	61,341		
1899 — Granite—Sawn only. Duty 20 p.c.			$ 420
1899 — Finished and polished. " 35 p.c.			12,371
1899 — Manufactures of, N.O.P. " 35 p.c.			32,734
1899 — Manufactures of stone, N.O.P. " 30 p.c.			14,623
			$60,148

TABLE 5.

STRUCTURAL MATERIALS.

ANNUAL PRODUCTION OF MARBLE.

Calendar Year.	Tons.	Value.
1886	501	$9,900
1887	242	6,224
1888	191	3,100
1889	83	980
1890	780	10,776
1891	240	1,752
1892	340	3,600
1893	590	5,100
1894	Nil.	Nil.
1895	200	2,000
1896	224	2,405
1897	Nil.	Nil.
1898	Nil.	Nil.
1899	Nil.	Nil.

TABLE 6.

STRUCTURAL MATERIALS.

IMPORTS OF MARBLE.

Fiscal Year.		Value.
1880		$ 63,015
1881		85,977
1882		109,505
1883		128,520
1884		108,771
1885		102,835
1886		117,752
1887		104,250
1888		94,681
1889		118,421
1890		99,353
1891		107,661
1892		106,268
1893		96,177
1894		94,657
1895		83,422
1896		90,065
1897		77,150
1898		$95,894
1899	Duty.	
Marble and manufactures of :—		
Marble sawn only	20 p. c.	$64,212
Finished and polished	35 "	19,961
Rough, not hammered or chiselled	15 "	2,012
Manufactures of, N.O.P	35 "	15,694
Total, marble and manufactures of		$101,879

Structural Materials.

Granite.

Table 7.

Structural Materials.

Annual Production of Granite.

Calendar Year.	Tons.	Value.
1886	6,062	$63,309
1887	21,217	142,506
1888	21,352	147,305
1889	10,197	79,624
1890	13,307	65,985
1891	13,637	70,056
1892	24,302	89,326
1893	22,521	94,393
1894	16,392	109,936
1895	19,238	84,838
1896	18,717	106,709
1897	10,345	61,934
1898	23,879	81,073
1899	13,418	90,542

Table 8.

Structural Materials.

Slate

Annual Production of Slate.

Calendar Year.	Tons.	Value.
1886	5,345	$64,675
1887	7,357	89,000
1888	5,314	90,689
1889	6,935	119,160
1890	6,368	100,250
1891	5,000	65,000
1892	5,180	69,070
1893	7,112	90,825
1894	.....	75,550
1895	.....	58,900
1896	.....	53,370
1897	.....	42,800
1898	.....	40,791
1899	.....	33,406

TABLE 9.

STRUCTURAL MATERIALS.

EXPORTS OF SLATE.

Calendar Year.	Tons.	Value.
1884	539	$6,845
1885	346	5,274
1886	34	495
1887	27	373
1888	22	475
1889	26	3,303
1890	12	153
1891	15	195
1892	87	2,038
1893	178	3,168
1894	187	3,610
1895	36	574
1896	301	8,913
1897	Nil.	Nil.
1898	Nil.	Nil.
1899	Nil.	Nil.

TABLE 10.

STRUCTURAL MATERIALS.

IMPORTS OF SLATE.

Fiscal Year.	Value.	Fiscal Year.	Value.
1880	$21,431	1890	$22,871
1881	22,184	1891	46,104
1882	24,543	1892	50,441
1883	24,968	1893	51,179
1884	28,816	1894	29,267
1885	28,169	1895	19,471
1886	27,852	1896	24,176
1887	27,845	1897	21,615
1888	23,151	1898	24,907
1889	41,370		

		Duty.	
1899	Slate and manufactures of—		
	Mantels	30 p. c.	$ 304
	Roofing slate	25 p. c. not over 75c. per square	9,096
	School writing slates	25 p. c.	11,558
	Slate pencils	25 p. c.	3,135
	Slate of all kinds and manufactures of, N.E.S.	30 p. c.	9,007
	Total		$33,100

Structural Materials.

Flagstone.

Table 11.

Structural Materials.

Production of Flagstone.

Calendar Year.	Quantity, Sq. ft.	Value.
1886	70,000	$ 7,875
1887	116,000	11,600
1888	64,800	6,580
1889	14,000	1,400
1890	17,865	1,643
1891	27,300	2,721
1892	13,700	1,869
1893	40,500	3,487
1894	152,700	5,298
1895	80,005	6,687
1896	.....	6,710
1897	.....	7,190
1898	.....	4,250
1899	.....	7,600

Table 12.

Structural Materials.

Imports of Flagstone.

Fiscal Year.	Tons.	Value.
1881	23	$ 241
1882	90	848
1883	10	99
1884	137	1,158
1885	205	1,756
1886	1,602	9,443
1887	1,316	10,966
1888	2,642	21,077
1889	1,669	15,451
1890	5,665	48,995
1891	3,770	36,348
1892	1,571	15,048
1893	884	8,500
1894	218	2,429
1895	15	84
1896	Nil.	Nil.
1897	13	227
1898*	587	1,540
1899	Nil.	Nil.

* Flagstones, dressed. (See Table 3).

Cement.

Cement.—The manufacture of cement is an industry which has been rapidly gaining in importance in Canada during the past few years. From a production in 1890, valued at less than $100,000 the output has reached in 1899 a value of $633,291. The value of the product of 1897 has been more than doubled, and the increase over 1898 has

been 58 per cent in quantity, and 59 per cent in value. The average price per barrel, was about the same as in 1898, viz. 84 cents for natural rock and $2 for Portland. Of the total output less than 19 per cent of the value was in natural rock cement, the balance over 81 per cent being Portland. The province of Ontario was the largest producer, turning out over 87 per cent of the whole product.

The number of works engaged in manufacturing was greater than in previous years by two, the total being eleven, viz; eight in Ontario, two in Quebec, and one in British Columbia. Natural rock cement was made at four works in Ontario and one in Quebec, while Portland cement was made by four works in Ontario, two in Quebec and one in British Columbia.

The two new works started up were the Georgian Bay Portland Cement Co., Ltd., at Owen Sound, Ont., afterwards called the Imperial Cement Co., Ltd., which only began operations late in the year, capacity 300 barrels a day, and the Beaver Portland Cement Company, Ltd., with works at Marlbank, Ontario, and head office at Montreal, now merged into the Canadian Portland Cement Co., Ltd.

In spite of the large increase in home production the imports of Portland cement have also increased rapidly during the past two years. The imports of Portland cement in 1899 were of the value of $467,994, the increase over 1898 being $112,730 or nearly 32 per cent.

TABLE 13.
STRUCTURAL MATERIALS.
ANNUAL PRODUCTION OF CEMENT.

Calendar Year.		Barrels.	Value.	Barrels.	Value.
1887				69,843	$ 81,909
1888				50,668	35,593
1889				90,474	69,790
1890				102,216	92,405
1891				93,473	108,561
1892				117,408	147,663
1893				158,597	194,015
1894				108,142	144,637
1895				128,294	173,675
1896				149,090	201,651
1897	Natural	85,450	$ 65,893	205,213	$275,273
	Portland	119,763	209,380		
1898	Natural	87,125	73,412	250,209	397,580
	Portland	163,084	324,168		
1899	Natural	141,387	119,308	396,753	633,291
	Portland	255,366	513,983		

Structural Materials.

Cement.

Table 14.

Structural Materials.

Exports of Cement.

Province.	Calendar Year.					
	1894.	1895.	1896.	1897.	1898.	1899.
Ontario	$339	$662	$484	$535	$632	$ 959
Quebec	42	30	625	109	604	1,134
Nova Scotia	101	245	219	.....	881	507
British Columbia	....	....	....	....	....	133
Totals	$482	$937	$1,328	$644	$2,117	$2,733

Table 15.

Structural Materials.

Imports of Cement in Bulk or Bags.

Fiscal Year.	Bushels.	Value.
1880	65	$ 28
1881	579	298
1882	386	86
1883	1,759	548
1884	4,626	1,236
1885	4,598	1,315
1886	6,808	1,851
1887	5,421	1,419
1888	23,919	5,787
1889	32,818	10,668
1890	21,055	5,443
1891	11,281	2,890
1892	14,351	3,394
1893	12,534	2,909
1894	9,027	2,618
1895	....	2,112
1896	.....	3,672
1897	...	4,318
1898	.....	3,263
1899*	.....	8,929

*Cement, N.E.S., duty 20 p.c.

TABLE 16.
STRUCTURAL MATERIALS.
IMPORTS OF HYDRAULIC CEMENT.

Fiscal Year.	Barrels.	Value.
1880	10,034	$ 10,306
1881	7,812	7,821
1882	11,945	13,410
1883	11,659	13,755
1884	8,606	9,514
1885	5,613	5,396
1886	6,164	6,028
1887	6,160	8,784
1888	5,636	7,522
1889	5,835	7,467
189	5,440	9,048
1891	3,515	6,152
1892	2,214	2,782
1893	4,896	8,060
1894	1,054	985
1895	5,333	7,001
1896	5,688	8,948
1897	2,494	3,937
	Cwt.	
1898	16,033	7,097
1899 (cement, hydraulic or waterlime)*	1,678	694

*Duty 12½c. per 100 lbs.

TABLE 17.
STRUCTURAL MATERIALS.
IMPORTS OF PORTLAND CEMENT.

Fiscal Year.	Barrels.	Value.
1880		$ 55,774
1881		45,646
1882		66,579
1883		102,537
1884		102,857
1885		111,521
1886		120,398
1887	102,750	148,054
1888	122,402	177,158
1889	122,273	179,406
1890	192,322	313,572
1891	183,728	304,648
1892	187,233	281,553
1893	229,492	316,179
1894	224,150	280,841
1895	196,281	242,813
1896	204.407	242,409
1897	210,871	252,587
	Cwt.	
1898	1,073,058	355,264
1899 (Portland or Roman)*	1,300,424	467,994

* Duty, 12½c. per 100 lbs.

Structural Materials.

Roofing Cement.

Table 18.
Structural Materials.
Production of Roofing Cement.

Calendar Year.	Tons.	Value.
1890	1,171	$ 6,502
1891	1,020	4,810
1892	800	12,000
1893	951	5,441
1894	815	3,978
1895	.....	3,153
1896	86	430
1897	Nil.	Nil.
1898	Nil.	Nil.
1899	Nil.	Nil.

Lime.

Table 19.
Structural Materials.
Annual Production of Lime.

Calendar Year.	Value.
1886	$283,755
1887	394,859
1888	339,951
1889	362,848
1890	412,308
1891	251,215
1892	411,270
1893	900,000
1894	900,000
1895	700,000
1896	650,000
1897	650,000
1898	650,000
1899	800,000

Table 20.
Structural Materials.
Exports of Lime.

Province.	Calendar Year.			
	1896.	1897.	1898.	1899.
Ontario	$25,500	$17,730	$ 31,465	$ 60,573
Quebec	18,067	21,786	15,800	5,595
Nova Scotia	3,195	2,390	245	388
New Brunswick	24,058	11,021	2,047	6,988
Manitoba	.....	250	.....	21
British Columbia	.....	.....	37	.....
Totals	$ 70,820	$ 53,177	$49,594	$ 73,565

TABLE 21.

STRUCTURAL MATERIALS.

IMPORTS OF LIME.

Fiscal Year.	Barrels.	Value.
1880	6,100	$ 6,013
1881	5,796	4,177
1882	5,064	5,365
1883	7,623	9,224
1884	10,804	11,200
1885	12,072	11,503
1886	11,021	9,347
1887	10,835	8,524
1888	10,142	7,537
1889	13,079	9,363
1890	8,149	5,360
1891	6,259	4,273
1892	6,132	4,241
1893	6,879	4,917
1894	6,766	4,907
1895	12,008	5,743
1896	10,239	7,331
1897	16,108	10,529
1898	12,850	9,002
1899 Duty 20 p.c.	15,720	11,124

TABLE 22.

STRUCTURAL MATERIALS.

ANNUAL PRODUCTION OF BUILDING BRICKS.

Calendar Year.	Value.
1886	$ 873,600
1887	986,689
1888	1,036,746
1889	1,273,884
1890	1,266,982
1891	1,061,536
1892	1,251,934
1893	1,800,000
1894	1,800,000
1895	1,670,000
1896	1,600,000
1897	1,600,000
1898	1,900,000
1899	2,195,000

Structural Materials.

Bricks.

Table 23.

Structural Materials.

Exports of Brick.

Province.	Calendar Years.									
	1895.		1896.		1897.		1898.		1899.	
	M	Value	M	Value	M	Value	M	Value	M	Value
		$		$		$		$		$
Ontario	1,053	4,420	266	1,473	178	940	9	59	45	406
Quebec	82	1,092	41	200	316	1,114	16	88	24	96
Nova Scotia	199	834	600	3,276	31	285	11	74	8	89
New Brunswick	321	2,319	76	729	48	340	23	155	86	516
British Columbia	.....	....	.....	.....	.....	.....	6	66	9	244
Totals	1,655	8,665	983	5,678	573	2,679	65	442	172	1,351

Table 24.

Structural Materials.

Building Bricks.

Imports of Building Bricks.

Fiscal Year.	Value.
1880	$ 2,067
1881	4,281
1882	24,572
1883	14,234
1884	20,258
1885	14,632
1886	5,929
1887	2,440
1888	20,720
1889	24,585
1890	12,500
1891	9,744
1892	5,075
1893	14,108
1894	18,320
1895	4,705
1896	23,189
1897	10,336
1898	6,652
1899 Duty 20 p.c.	21,306

Imports of paving bricks in 1898: Value, $2,337; duty, 20 p.c.
" " 1899: " $23,648; "

Table 25.

Structural Materials.

Production of Terra Cotta, etc.

Calendar Year.	Value.
1888	$ 49,800
1889	Not available.
1890	90,000
1891	113,103
1892	97,239
1893	55,704
1894	65,600
1895	195,123
1896	83,855
1897	155.595
1898	167,902
1899	220,258

Table 26.

Structural Materials.

Production of Sewer Pipes, etc.

Calendar Year.	Value.
1888	$266,320
1889	Not available.
1890	348,000
1891	227,300
1892	367,660
1893	350,000
1894	250,325
1895	257,045
1896	153,875
1897	164,250
1898	181,717
1899	161,546

STRUCTURAL MATERIALS.

Drain Tiles and Sewer Pipes.

TABLE 27.

STRUCTURAL MATERIALS.

IMPORTS OF DRAIN TILES AND SEWER PIPES.

Fiscal Year.			Value.
1880			$ 33,796
1881			37,368
1882			70,065
1883			70,699
1884			71,755
1885			69,589
1886			57,953
1887			71,203
1888			101,257
1889			83,215
1890			77,434
1891			87,195
1892			59,537
1893			39,001
1894			24,625
1895			21,053
1896			19,296
1897			34,286
1898			29,611
		Duty.	
1899	Drain tile, not glazed	20 p. c.	$ 1,827
	Drain pipes, sewer pipes, chimney linings or vents, chimney tops and inverted blocks, glazed or unglazed	35 "	32,071
	Total		$33,898

Pottery.

TABLE 28.

STRUCTURAL MATERIALS.

ANNUAL PRODUCTION OF POTTERY.

Calendar Year.	Value.
1888	$ 27,750
1889	Not available.
1890	195,242
1891	258,844
1892	265,811
1893	213,186
1894	162,144
1895	151,588
1896	163,427
1897	129,629
1898	214,675
1899	185,000

TABLE 29.

STRUCTURAL MATERIALS.

IMPORTS OF EARTHENWARE.

Earthenware.

Fiscal Year.	Value.	Fiscal Year.	Value.
1880	$322,333	1890	$695,206
1881	439,029	1891	634,907
1882	646,734	1892	748,810
1883	657,886	1893	709,737
1884	544,586	1894	695,514
1885	511,853	1895	547,935
1886	599,269	1896	575,493
1887	750,691	1897	595,822
1888	697,082	1898	675,874
1889	697,949		

		Duty.	
1899	Earthenware and china :—		
	Baths, tubs and washstands, of earthenware, stone, cement or clay, or of other material, N.O.P.	30 p.c.	$ 26,413
	Brown or coloured earthen and stoneware, and Rockingham ware	30 p.c.	12,276
	Decorated, printed or sponged, and all earthenware, N.E.S	30 p.c.	234,060
	Demijohns, churns and crocks	30 p.c.	3,133
	White granite or ironstone ware, C.C. or cream coloured ware	30 p.c.	203,404
	China and porcelain ware	30 p.c.	273,900
	Earthenware tiles	35 p.c.	32,235
	Manufactures of earthenware, N.E.S.	30 p.c.	131,306
	Total		916,727

TABLE 30.

STRUCTURAL MATERIALS.

EXPORTS OF SAND AND GRAVEL.

Sand and Gravel.

Calendar Year.	Tons.	Value.
		$
1893	329,116	121,795
1894	324,656	86,940
1895	277,162	118,359
1896	224,769	80,110
1897	152,963	76,729
1898	165,954	90,498
1899 Ontario	240,306	94,810
1899 Quebec	1,744	5,230
1899 Nova Scotia	400	1,600
Total	242,450	101,640

MISCELLANEOUS.

MISCELLANEOUS.

Antimony.

Antimony :—The production of antimony which was renewed at the Rawdon mines in Nova Scotia in 1898, after an idleness of six years appears not to have been continued during 1899. No returns were received.

TABLE 1.

MISCELLANEOUS.

ANNUAL PRODUCTION OF ANTIMONY ORE.

Calendar Year.	Tons.	Value.
1886	665	$31,490
1887	584	10,860
1888	345	3,696
1889	55	1,100
1890	26½	625
1891	10	60
1892 to 1897	Nil	Nil
1898	1,344	20,000
1899	Nil	Nil

TABLE 2.

MISCELLANEOUS.

EXPORTS OF ANTIMONY ORES.

Calendar Year.	Tons.	Value.	Calendar Year.	Tons.	Value.
1880	40	$ 1,948	1886	665	$31,490
1881	34	3,308	1887	229	9,720
1882	323	11,673	1888	352½	6,894
1883	165	4,200	1889	30	695
1884	483	17,875	1890	38	1,000
1885	758	36,250	1891*	3½	60
1898				1,232	15,295
1899, Nova Scotia				6¾	190

*No exports between 1891 and 1898.

Antimony.

TABLE 3.

MISCELLANEOUS.

IMPORTS OF ANTIMONY.

Fiscal Year.		Pounds.	Value.
1880		42,247	$ 5,903
1881			7,060
1882		183,597	15,044
1883		105,346	10,355
1884		445,600	15,564
1885		82,012	8,182
1886		89,787	6,951
1887		87,827	7,122
1888		120,125	12,242
1889		119,034	11,206
1890		117,066	17,439
1891		114,084	17,483
1892		180,308	17,680
1893		181,823	14,771
1894		139,571	12,249
1895		79,707	6,131
1896		163,209	9,557
1897		134,661	8,031
1898		156,451	12,350
	Duty.		
1899 Antimony, or regulus of, not ground or pulverized or otherwise manufactured.	Free.	157,599	$12,890
1899 Antimony salts	"	131,467	3,961
Total		289,066	16,851

Arsenic.

Arsenic.—A production of arsenic is reported in 1899 of 57 tons valued at $4,872. This is the product chiefly of the Canadian Gold Fields, Limited, at Deloro, Hastings county, Ontario, and with the exception of some small output in 1894 is the first product since 1891. The ore which consists of irregular veinlike masses of quartz containing a considerable amount of arsenopyrite (mispickel), besides smaller amounts of other sulphides and carbonates, is mined primarily for the gold which is finely disseminated through the sulphides. A new plant was erected by the present company for refining the arsenic. It is situated in the old mill which originally contained the machinery used for this purpose. The finished product is sold in New York where there is said to be a good demand for it.

Miscellaneous.

Arsenic.

Table 4.

Miscellaneous.

Annual Production of Arsenic.

Calendar Year.	Tons.	Value.
1885	440	$17,600
1886	120	5,460
1887	30	1,200
1888	30	1,200
1889	Nil.	Nil.
1890	25	1,500
1891	20	1,000
1892	Nil.	Nil.
1893	"	"
1894	7	420
1895	Nil.	Nil.
1896	"	"
1897	"	"
1898	"	"
1899	57	4,872

Table 5.

Miscellaneous.

Imports of Arsenic.

Fiscal Year.	Pounds.	Value.
1880	18,197	$ 576
1881	31,417	1,070
1882	138,920	3,962
1883	51,953	1,812
1884	19,337	773
1885	49,080	1,566
1886	30,181	961
1887	32,436	1,116
1888	27,510	1,016
1889	69,269	2,434
1890	138,509	4,474
1891	115,248	4,027
1892	302,958	9,365
1893	447,079	12,907
1894	292,505	10,018
1895	1,115,697	31,932
1896	664,854	27,523
1897	152,275	8,378
1898	291,967	14,270
1899	Duty free. 582,383	24,203

Table 6.

Miscellaneous.

Production of Felspar.

Miscellaneous.

Felspar.

Calendar Year.	Tons.	Value.
1890	700	$3,500
1891	685	3,425
1892	175	525
1893	575	4,525
1894	Nil.	Nil.
1895	.....	*2,545
1896	972	*2,583
1897	1,400	3,290
1898	2,500	6,250
1899	3,000	6,000

* Exports.

Table 7.

Miscellaneous.

Production of Fireclay.

Fireclay.

Calendar Year.	Tons.	Value.
1889	400	$4,800
1890	Nil.	Nil.
1891	250	750
1892	1,991	4,467
1893	540	700
1894	539	2,167
1895	1,329	3,492
1896	842	1,805
1897	2,118	5,759
1898	670	1,680
1899	599	1,295

Moulding Sand :—The moulding sand for which statistics appear is nearly all the production of western Ontario, the figures being obtained from railway shipments. Such sands are doubtlessly available and used locally at various places but records of production have not been obtained.

Moulding Sand.

Miscellaneous.

Moulding Sand.

Table 8.

Miscellaneous.

Production of Moulding Sand.

Calendar Year.	Tons.	Value.
1887	160	$ 800
1888	169	845
1889	170	850
1890	320	1,410
1891	230	1,000
1892	345	1,380
1893	4,370	9,086
1894	6,214	12,428
1895	6,765	13,530
1896	5,739	11,478
1897	5,485	10,931
1898	10,572	21,038
1899	13,724	27,430

Platinum.

Table 9.

Miscellaneous.

Annual Production of Platinum.

Calendar Year.	Value.
1887	$ 5,600
1888	6,000
1889	3,500
1890	4,500
1891	10,000
1892	3,500
1893	1,800
1894	950
1895	3,800
1896	750
1897	1,600
1898	1,500
1899	825

TABLE 10.

MISCELLANEOUS.

IMPORTS OF PLATINUM.

Fiscal Year.	Value.
1883	$ 113
1884	576
1885	792
1886	1,154
1887	1,422
1888	13,475
1889	3,167
1890	5,215
1891	4,055
1892	1,952
1893	14,082
1894	7,151
1895	3,937
1896	6,185
1897	9,031
1898	9,781
1899*	9,671

* Platinum wire and platinum in bars, strips, sheets or plates; platinum retorts, pans, condensers, tubing and pipe, imported by manufacturers of sulphuric acid for use in their works. Duty free.

TABLE 11.

MISCELLANEOUS.

ANNUAL PRODUCTION OF QUARTZ.

Calendar Year.	Tons.	Value.
1890	200	$ 1,000
1891	.....	.....
1892	.....	.....
1893	100	500
1894	.....	.....
1895	.....	.....
1896	10	50
1897	.....	.....
1898	284	570
1899	600	1,260

MISCELLANEOUS.

Quartz.

TABLE 12.

MISCELLANEOUS.

IMPORTS OF 'SILEX' CRYSTALLIZED QUARTZ.

Fiscal Year.	Cwt.	Value.
1880	5,252	$ 2,290
1881	3,251	1,659
1882	3,283	1,678
1883	3,543	2,058
1884	3,259	1,709
1885	3,527	1,443
1886	2,520	1,313
1887	14,533	5,073
1888	4,808	2,385
1889	5,130	1,211
1890	1,768	2,617
1891	3,674	1,929
1892	1,429	1,244
1893	2,447	1,301
1894	2,451	1,521
1895	2,882	1,881
1896	3,289	2,174
1897	2,564	3,415
1898	3,104	2,773
1899 Duty free.	3,951	2,595

TABLE 13.

MISCELLANEOUS.

Soapstone.

ANNUAL PRODUCTION OF SOAPSTONE.

Calendar Year.	Tons.	Value.
1886	50	$ 400
1887	100	800
1888	140	280
1889	195	1,170
1890	917	1,239
1891	Nil	Nil
1892	1,374	6,240
1893	717	1,920
1894	916	1,640
1895	475	2,138
1896	410	1,230
1897	157	350
1898	405	1,000
1899	450	1,960

TABLE 14.

MISCELLANEOUS.

IMPORTS OF TIN AND TINWARE.

Fiscal Year.	Value.	Fiscal Year.	Value.
1880	$ 281,880	1890	1,289,756
1881	413,924	1891	1,206,918
1882	790,285	1892	1,594,205
1883	1,274,150	1893	1,242,994
1884	1,018,493	1894	1,310,389
1885	1,060,883	1895	973,397
1886	1,117,368	1896	1,237,684
1887	1,187,312	1897	1,274,108
1888	1,164,273	1898	1,550,851
1889	1,243,794		

		Duty.	
1899	Tin crystals	Free.	$ 2,574
	Tin in blocks, pigs and bars	"	306,085
	Tin plates and sheets	"	927,036
	Tin foil	"	38,401
	Tin strip waste	"	3,216
	Tin and manufactures of :—		
	Tin plate in sheets, decorated	25 p. c.	857
	Tinware, plain, japanned, or lithographed, and all manufactures of tin, N.E.S	25 "	94,644
	Total		$1,372,813

Tripolite :—Direct returns of the production of tripolite at the Nova Scotia deposits in 1899 were not received, but Dr. Gilpin, inspector of Mines for the province, has estimated the production of tripolite and silica at about 893 gross tons, or in round numbers say about 1,000 short tons. At an average value per ton of $15 this output would approximate in value $15,000. There has been a small production since 1896.

Tripolite

TABLE 15.

MISCELLANEOUS.

PRODUCTION OF TRIPOLITE.

Calendar Year.	Tons.	Value.
		$
1896	664	9,960
1897	15	150
1898	1,017	16,660
1899	1,000	15,000

MISCELLANEOUS.

Whiting.

TABLE 16.

MISCELLANEOUS.

IMPORTS OF WHITING.

Fiscal Year.	Cwt.	Value.
1880	84,115	$26,092
1881	47,480	16,637
1882	36,270	16,318
1883	76,012	29,334
1884	76,268	28,230
1885	67,441	23,492
1886	65,124	25,533
1887	47,246	15,191
1888	76,619	20,508
1889	84,658	22,735
1890	96,243	27,471
1891	84,679	27,504
1892	102,985	26,867
1893	88,835	25,563
1894	103,633	26,649
1895	102,751	25,441
1896	113,791	27,322
1897	102,453	22,541
1898	166,293	25,761
*1899	134,884	34,310

* Whiting or whitening, gilders' whiting and Paris white. Duty free.

TABLE 17.

MISCELLANEOUS.

Chalk.

IMPORTS OF CHALK.

Fiscal Year.	Value.
1880	$2,117
1881	2,768
1882	2,882
1883	5,067
1884	2,589
1885	8,003
1886	6,583
1887	5,635
1888	5,865
1889	5,336
1890	7,221
1891	8,193
1892	9,558
1893	9,966
1894	11,308
1895	7,730
1896	6,467
1897	7,432
1898	9,338
*1899	10,461

* Chalk prepared. Duty 20 p. c.

Zinc:—The Grand Calumet Mining Company of Ottawa which in 1898 was working the blende and galena deposits on Calumet Island, Pontiac county, Quebec, transferred their operations in 1899 to the Zenith mine north of Nipigon Bay. Lake Superior, Ontario. MISCELLANEOUS. Zinc.

This deposit has been known for many years. It was visited by Dr. Selwyn in 1895. At that time several hundred tons of ore had been raised but as there was no available road from the mine the ore was not shipped and nothing further appears to have been accomplished until last year.

The present owners shipped in 1899, 865 gross tons of ore averaging 42 per cent. zinc, yielding therefore about 407 tons of metallic zinc.

In 1898, the production of zinc from the Calumet mine was 394 tons.

TABLE 18.

MISCELLANEOUS.

IMPORTS OF ZINC IN BLOCKS, PIGS AND SHEETS.

Fiscal Year.	Cwt.	Value.
1880	13,805	$67,881
1881	20,920	94,015
1882	15,021	76,631
1883	22,765	94,799
1884	18,945	77,373
1885	20,954	70,598
1886	23,146	85,599
1887	26,142	98,557
1888	16,407	65,827
1889	19,782	83,935
1890	18,236	92,530
1891	17,984	105,023
1892	21,881	127,302
1893	26,446	124,360
1894	20,774	90,680
1895	15,061	63,373
1896	20,223	80,784
1897	11,946	57,754
1898	35,148	112,785
1899 .. Duty free	18,785	107,477

MISCELLANEOUS.

Zinc.

TABLE 19.

MISCELLANEOUS.

IMPORTS OF SPELTER.

Fiscal Year.	Cwt.	Value.
1880	1,073	$ 5,310
1881	2,904	12,276
1882	1,654	7,779
1883	1,274	5,196
1884	2,239	10,417
1885	3,325	10,875
1886	5,432	18,238
1887	6,908	25,007
1888	7,772	29,762
1889	8,750	37,403
1890	14,570	71,122
1891	6,249	31,459
1892	13,909	62,550
1893	10,721	49,822
1894	8,423	35,615
1895	9,249	30,245
1896	10,897	40,548
1897	8,342	32,826
1898	2,794	13,561
1899*.....Duty free	5,450	29,687

* Spelter in blocks and pigs.

TABLE 20.

MISCELLANEOUS.

IMPORTS OF ZINC, MANUFACTURES OF.

Fiscal Year.	Value.	Fiscal Year.	Value.
1880	$ 8,327	1890	6,472
1881	20,178	1891	7,178
1882	15,526	1892	7,563
1883	22,599	1893	7,464
1884	11,952	1894	6,193
1885	9,459	1895	5,581
1886	7,345	1896	6,290
1887	6,561	1897	5,145
1888	7,402	1898	10,503
1889	7,233		

		Duty.	
1899	Zinc, seamless drawn tubing	Free.	$ 5,037
	" manufactures of, N.O.P	25 p. c.	9,624
	Total		14,661

INDEX.

	(s, PAGE.
Letter of Transmittal	3
Notes	5
Introduction	7
Summary of Production, 1886 to 1899	Opposite 8
" Exports	10
" Imports	11
Abrasive Materials—	
Grindstones	11
Buhrstones	15
Emery	15
Pumice stone	16
Asbestus	16
Chromite	19
Coal	20
Coke	35
Copper	37
Graphite	45
Gypsum	47
Iron	51
Lead	71
Manganese	77
Mercury	79
Mica	80
Mineral Pigments—	
Ochres	81
Baryta	83
Mineral Water	84
Natural Gas	86
Nickel	86
Petroleum	89
Phosphate	95
Precious Metals—	
Gold	97
Silver	108
Pyrites	113
Salt	114
Structural Materials—	
Building stone	117
Marble	119
Granite	120
Slate	120
Flagstone	122
Cement	122
Lime	126

Structural Materials—*Cont.* PAGE
Brick 128
Terra Cotta 129
Drain Tiles and Sewer Pipes 130
Pottery and Earthenware 130
Sand and Gravel 131

Miscellaneous—
Antimony 132
Arsenic 133
Felspar 135
Fire-clay 135
Moulding Sand 135
Platinum 136
Quartz and Silex 137
Steatite (Soapstone) 138
Tin 139
Tripolite 139
Whiting and Chalk 140
Zinc 141

INDEX—VOL. XII.

(New Series.)

ABBREVIATIONS.

Al.	District of Alberta.	N.W.T.	North-west Territory.
B.C.	Province of British Columbia.	O.	Province of Ontario.
N.E.T.	North-east Territory.	Q.	Province of Quebec.
N.S.	Province of Nova Scotia.	Sask.	District of Saskatchewan.

PAGE.

Abrasive materials, statistics.... 11-16 S
grindstones..... 11-14 S
buhrstones..... 15 S
emery..... 15 S
pumice stone..... 16 S
Acadia, Lake, N.B., origin of.... 11 M
Actinolite, production..... 8 S
slates of the gold series..... 15 B
Adams creek, Yukon district, gold and silver assay..... 44 R
Adams, Dr. F. D., work by.....122-131 A
exploration by..... 9 J
quoted on anorthosite rocks... 12 J
quoted on the origin of apatite. 16 O
Ætna apatite mine, Lièvre river, Q., rocks of..... 102 J
Agriculture in Kootenay district, B.C., state of..... 102 A
Aigle, Lac à l', Ottawa county, Q., rocks at..... 48 J
Alberta, experimental borings in northern..... 11-15 A
Albertite in N.B., note on..... 157 A
Alfred township, Prescott county, O., rocks of..... 36 J
photograph of contorted gneiss. 36 J
outcrops in..... 80 J
Trenton limestone..... 87 J
Allan's iron mine, North Crosby township, O., description of 36 I
Allan's apatite mine, Portland West township, Q..... 120 J
All Gold creek, Yukon, note on. 51 A
Allophane from Yukon district, note on..... 18 R
Altaite from East Kootenay district, B.C., note on..... 19 R
Alum, import of..... 11 S
Aluminium, import of..... 11 S
Amazonstone from James bay, N.E.T., note on..... 19 R
Amherst township, Ottawa county, Q., rocks in..... 38 J
deposits of kaolin..... 135 J
Ami, Dr. H. M., work by..... 199, 204 A, 51-77 G
Ammonites of Atlin district, B. C., examined by Dr. T. W. Stanton..... 26 B

PAGE.

Ammophila arenaria on Sable island.....213, 215 A
Amphibole seen at Little Rapids mine, note on..... 37 O
Anaconda claims, Atlin city, B. C., magnesite examined... 22 R
Anaconda group, B.C., rocks of. 70 A
Anderson, Cape, Hudson bay, gold and silver assay..... 40 R
Andesites of Atlin district, B.C. 28 B
Andover quarter-sheet map, surface geology of..... 1-41 M
See New Brunswick.
Animals, fur-bearing, in Atlin district, B.C..... 13 B
Animikie rocks, note on..... 7 A
of Great Slave lake.....106, 107 A
Annunciation village, Marchand township, Q., rocks at.... 28 J
Anorthosite rocks, origin and age 12 J
Dr. Adams and Dr. Selwyn on 12 J
relations of limestones to..... 13 J
distribution of..... 14 J
Anstruther, township of, O., rocks of..... 123 A
Anthracite from 10 m. west of Dugdale, Yukon district, description and analysis of. 30 R
Anticlines, in Carleton county, O. 135 A
of Renfrew gold district, N.S.170,173 A
of Upper Newport gold district, N.S..... 181 A
of Salmon river, N.S..... 183 A
of Atlin district, B.C..... 25 B
Wakefield township, Q..... 72 J
along Nation river, Q..... 79 J
in the valley of the Ottawa.. 88 J
Antimony, production..... 8, 132 S
export.....10, 132 S
import.....11, 133 S
specimens sent to Paris..... 156 A
occurrence in York county, N.B 40 M
Apatite, vicinity of Ottawa, O... 41, 42 G
occurrence, Ottawa county, Q 52-54 J
north of the Ottawa.....94-105 J
occurrence in pyroxene..... 97, 98 J
character of deposits..... 99 J
contact, character of..... 100 J
association of mica and..... 103 J

	PAGE.
Apatite occurrence of, north of Ottawa	11, 66 o
first discovery and area of rocks	11 o
Sterry Hunt quoted on	12 o
J. W. Dawson quoted on	12 o
Harrington and Torrence on	13 o
other opinions on mode of occurrence and origin	14 o
beds and veins cut the gneiss	17 o
genetic relation of pyroxenite and	17 o
geological relations	18 o
a basic plutonic rock	19 o
occurrence in true veins	19 o
accompanied with pyroxenite	20 o
veins cutting pegmatite	22 o
veins cutting syenite	25 o
vein nature of deposits probable	26 o
vein minerals	27 o
crystallized pyroxene in veins of	27 o
phlogopite accompanying	20 o
description of crystals	34 o
analysis of Canadian	34 o
veins, minerals in	36 o
characters of occurrences	58 o
veins in Sweden, similar to Canadian	59 o
veins, origin of	60 o
literature consulted on	82 o
rocks, plates of	84 o
Appropriations and expenditure	224 A
Archæan rocks of the Ottawa valley	1-84 o
field of investigation and nature of work	3 o
gneisses from the neighbourhood of Ottawa	3-11 o
apatite and mica north of Ottawa	11-66 o
occurrences of graphite	66-82 o
literature consulted	82-84 o
rocks, plates of	84 o
Ardoise gold district, N.S., description of	182 A
Argenteuil, Ottawa and Pontiac counties, Q., geology of	1-143 J
area examined and described	5 J
general character of rocks	6 J
early surveys and explorations	7-9 J
character of country	9 J
agricultural resources	11 J
country north of the Ottawa river	16, 17 J
district between Rouge and North rivers	17-32 J
area between Rouge and Nation rivers	32-46 J
between Nation and Lièvre rivers	47-53 J
Lièvre river	53-59 J
area between Lièvre and Gatineau rivers	59-67 J
the Upper Gatineau	67-71 J
Hull, Buckingham and Wakefield district	72-76 J
sedimentary deposits in the Ottawa valley	76-79 J
Potsdam sandstone	79-81 J
Calciferous formation	81-83 J

	PAGE.
Argenteuil, Ottawa and Pontiac counties, Q., Chazy formation	84-86 J
Black River limestone	86 J
Trenton limestone	87 J
Utica shale	88-90 J
surface geology	90-94 J
economic minerals	94 J
list of fossils	139-143 J
Arisaig district, Antigonish county, N.S., analyses of hematite	35, 36 R
Arkose from Lake Manai, N.W. T., examined	34 C
beds, in Ottawa valley	77 J
Arsenic, production	8, 134 S
import	11, 134 S
Asbestus, production	7, 8, 9, 17, 18 S
export	10, 18 S
import	11, 19 S
mine, Perkins Mill, Q., note on	73 J
occurences, north of Ottawa R.	105 J
Asphaltum, import of	11 S
Athabasca Landing, Alta., equivalency of Cretaceous rocks	14 A
Athapapuskow lake, Sask., rocks of	111 A
Atlin City, B.C., note on	55 A
magnesite examined	22 R
Atlin lake, B.C., description of	55 A
rocks on	59 A
earthquake on	62 A
analysis of water	59 R
elevation of	7 B
climate of	11 B
summary of temperature	12 B
Atlin mining district, B.C., report on the	1-48 B
history of the district	53 A, 5 B
accessibility	75 A, 6 B
lakes	7 B
rivers	8-10 B
terraces	10 B
climate, fauna and flora	73 A, 11-13 B
glaciation	13-15 B
general geology	73 A, 15-18 B
the gold series	67 A, 18-21 B
magnesite	21-23 B
sandstones, conglomerates	23-26 B
granites	26-29 B
granite porphyry	29 B
recent eruptives	30-32 B
pre-glacial gravels	32-34 B
origin and output of placer gold	34 B
post-glacial channels	35 B
Willow and Thron creeks	37 B
Stephen dyke	38-44 B
quartz and lode mining	44-46 B
water analysis	46 B
note on map	48 B
Atlin river, B.C., size of	59 A
description of	8 B
Augite andesite, composition of	29 B
phlogopites	48 O
porphyrite, Crown Hill mine, Q.	57 O
Auriferous gravels, Yukon district	27 A
Australia, exports to	10 S

	PAGE.
Australia creek, Yukon, yield of gold	51 A
Aylmer, Q., Chazy limestones at	29 G
Chazy shales	32 G
Aylwin township, Q., mica of	66 J
Babiche rapid, Lièvre river, Q., graphite of	57 J
Bagot township, Renfrew county, O., mines of	55-66 I
Bailey, Prof. L. W., work by	155-162 A
Bangatt lake, Ottawa county, Q., rocks at	62 J
Banksian pine, N. W. T.	111, 112 A
Bannockburn gold mine, O., closed	129 A
Barite. *See* Baryta.	
Bark lake, Argenteuil county, Q., rocks at	25 J
Barlow, Dr. A. E., work by	122-131 A
rocks examined by	29-36 C
Baryta, production	8, 83 S
import	84 S
in Huntley township, O., note on	19 R
deposits north of the Ottawa	134 J
in Hull township, Q., note on	43 G
Basalts of Atlin district, B.C.	28 B
Baskatong creek, Gatineau river, Q., rocks at	70 J
Bastard township, Leeds county, O., occurrence of hæmatite	79 I
Bathurst township, Lanark county, O., occurrence of magnetite	45, 46 I
occurrence of hæmatite	74, 75 I
Bearbrook, O., borings near	11 G
Bear creek, Ottawa county, Q., rocks at	47 J
Bear lake, Ottawa county, Q., rocks at	47 J
Bear river, Mackenzie river, description of	7 C
trend of valley	8 C
description of canyon	9 C
Beaufort, Carleton county, N.B., gold and silver assay	38 R
Beaver Lodge lake, Camsell river, N.W.T., note on	20 C
Beccaguimi river, N.B., geology of	12 M
Beccaquimec valley, N.B., Cambro-Silurian fossils	161 A
Bedford township, Frontenac county, O., description of mines	20-29 I
occurrence of hæmatite	76 I
galena examined	21 R
graphite examined	62 R
Beechwood, Ottawa, area of Utica shale	22 G
Black River limestone	27 G
Belgium, exports to	10 S
Bell, Dr. R., work by	103 A
exploration by	8 J
quoted on the origin of apatite	14 O
Bell, J. M., work by	104, 105 A
report by	5-36 C
Bells Corners, Carleton county, O., rocks at	34 G
Belmont, O., gold mine, note on	128 A
iron mine, note on	129 A
Bennett lake, Bathurst township, O., occurrence of hæmatite	80 I
Bevan lake, Argenteuil county, Q., rocks at	25 J
Big Bay lake, Ottawa county, Q., rocks at	45 J
Big lake, Argenteuil county, Q., band of limestone	25 J
deposit of mica	114 J
Big Nomininge lake, Ottawa county, Q., rocks of	32 J
Big Salmon river, Yukon district, gold and silver assay	44 R
Big Whitefish lake, Nation river, Q., rocks at	42 J
Biggar ridge, Carleton county, N.B., gold and silver assay	38 R
Biotite schists of Atlin district, B.C	23 B
granite, from Great Bear lake district, examined	31 C
Birch creek, B.C., description of	63 A, 42 B
Birch lake, Frontenac county, O., graphite examined	21 R
Birch mountains, B.C., description of	55 A
rocks of	69 A
Birds, Canadian, Catalogue of, in press	210 A
Bismuth, import of	11 S
Bittobee creek and lake, Ottawa county, Q., rocks at	64 J
Bituminous shale in N.B., note on	157 A
Bituminous substances, import of	11 S
Black bay, Nation river, Q., calciferous formation at	82 J
Black bay iron mine, Bagot township, O., description of	64-66 I
sketch plan of	64 I
Black Lake iron mine, Bedford township, O., description of	28 I
Black River limestone in the vicinity of Ottawa	26-29 G
photograph of	28 G
list of fossils	69-73 G
in the Ottawa valley	86 J
list of fossils	141 J
Blanche lake, Mulgrave township, Q., deposit of asbestus	107 J
Blanche river, Ottawa county, Q., description of	50 J
branches of	52 J
Blast furnace slag, import of	11 S
Bluff Point iron mine, Bagot township, O., description of	55-57 I
plan of mine	56 I
history	57 I
microscopic examination of rocks	81 I
Blythfield township, Renfrew county, O., graphite examined	62 R
Bog iron ore in Sunbury county, N.B	40 M
Bog manganese, occurrence in New Brunswick	40 M

	PAGE.
Bogs in Gloucester and Osgoode township, O.	12 G
Bolton lake, N.B., note on	15 M
Bonanza creek, Yukon, description of	30-36 A
tributaries	30 A
country rocks	31 A
gravels	32 A
quartz-drift	33 A
gold contents of gravels	34 A
character of gold	36 A
sericite examined	24 R
Bonanza gold-bearing gulches, Yukon, description of	36 A
Borax, import of	11 S
Borings, experimental, in northern Alberta	11-15 A
cause of stoppage	14 A
Botanical work	210 A
collections determined	211 A
Bouchette township, Ottawa county, Q., occurrence of sphalerite	25 R
note on mica deposits	127 J
Boulder-clay and boulders in New Brunswick	26, 27 M
Boulder ridges in Hull, Q.	17 G
beach, Rigaud mountain	93 J
Boulder creek, Atlin district, B.C., description	62 A, 42 B
Boulders, in quartz-drift	24 A
transport of, Atlin district, B.C.	73 A
Boyd, W. H., work by	5 B
Brass, import of	11 S
Brick clay, occurrence in New Brunswick	41 M
Brick-yards in the vicinity of Ottawa, O.	48 G
Bricks, production	7, 8, 127 S
export	10, 128 S
import	11, 128 S
Britannia, Carleton county, O., Chazy shales at	32 G
British Columbia, work in	52-103 A
Atlin district	52-75 A
West Kootenay	75-86 A
East Kootenay	87-103 A
mineral production	8 S
production of coal	33-35 S
" copper	44 S
" iron	53, 54 S
export of iron	55-59 S
production of lead	76 S
" gold	106-108 S
" silver	111, 112 S
British Guiana, exports to	10 S
British West Indies, exports to	10 S
Broadbent, R. L., work by	191 A
Brochet lake, Ottawa county, Q., rocks at	48 J
Brock, R. W., work by	75-86 A
Brome mountain, Q., rocks of	139 A
Bronze, German silver and pewter, import of	11 S
Brougham township, Renfrew county, O., occurrence of molybdenite	23 R
Brown's mica mine, Hull township, Q., note on	124 J
Brown's wharf, Ottawa river, O., Calciferous formation near.	83 J
Chazy formation	85 J
Brulé lake, O., rocks at	120 A
Buckingham, Q., rocks at	81 J
Buckingham township, Ottawa county, Q., geology of	72-76 J
mica mines in	113, 133 J
on the occurrence of graphite	66-73 O
Buhrstones, import of	11, 15 S
Building stone, production	7, 8, 117 S
import	11, 118 S
export	117 S
in Dorchester, N.B.	201 A
in the basin of the Ottawa	136 J
Bull river, B.C., rocks of	98 A
Burke's mica mine, Hull township, Q.	39 G, 123 J
Burntwood lake, N.W.T., rocks of	113 A
Burntwood river, N. W. T., description of	112 A
Burton City, camp, West Kootenay, B.C.	85 A
Bygrove iron mine, South Sherbrooke township, O., description of	32-34 I
Calabogie iron mines, Bagot township, O., plan of	58 I
microscopic examination of rocks	81 I
Calciferous formation in vicinity of Ottawa	133 A
list of fossils	75 G, 139 J
in the valley of the Ottawa	81-83 J
Calcite and mica, figure of section	24 O
Caldwell iron mine, Lavant township, O., description of	52-54 I
Caledonia, O., note on mineral springs	137 A
Caledonia township, O., Utica shale formation	89 J
Calumet, Argenteuil county, Q., rocks in the vicinity of	24 J
Calumet township, Pontiac county, Q., danaite examined	19 R
Cambrian series at Richmond gulf, Hudson bay	143 A
and Silurian rocks, relations of, N.B.	161 A
of Cape Breton	167, 188 A
Lower, rocks at Great Bear lake	26 C
Cambro-Silurian rock in New Brunswick	36 M
fossils, Beccaquimec valley, N.B.	161 A
Cameron, A., work by	169 A
Cameron lake, Ottawa county, Q., rocks of	34 J
Cameron's mine, Grenville, Q., deposits of mica	113 J

	PAGE.
Campbell's iron mine, Bagot township, O., description of	60 I
microscopic examination of rocks	82 I
Campbellton, N.B., examination for iron	149 A
Camsell river, Great Bear lake, description of	18 C
Canada Atlantic Railway, elevations in the vicinity of Ottawa	7-9 G
Canadian Birds, Catalogue of, in the press	210 A
Canadian Pacific Railway, elevations in the vicinity of Ottawa	7-9 G
Canadian Plants, Catalogue of, part vii prepared	210 A
Cañon mining claim, B.C., quartz of	70 A
Cantley, Hull township, Q., bands of limestone	74 J
marine shells at	92 J
Cape Breton island, rocks, fossils and topography	187-189 A
production of coal	31 S
Cape Hope island, James bay, N.E.T., gold and silver assay	39 R
Carboniferous areas of New Brunswick	6 M
denudation	16 M
boulder-clay in	26 M
sandstones	36 M
destruction of the forest	39 M
Carboniferous and Devonian rocks, relations of, N.S. and N.B	201-203 A
Cardiff, township of, O., mica mining	130 A
Cariboo creek, West Kootenay, description of	78 A
Cariboo plentiful at Great Bear Lake	16 C
Carleton county, N.B., arable lands of	154 A
list of striæ	25 M
Cascade mica mine, Gatineau river, Q., rocks of	42 O
microscopic description of contact rock	43 O
Cassidy's mica mine, Hull township, Q	126 J
Cassiterite from Yukon district, description of	16 R
Cavendish and Harvey townships, O., rocks of	123 A
Cèdres, Rapide des, Lièvre river, Q., rocks at	58 J
Celestite from Grand Manitoulin island, O., note on	19 R
Cement, production	7, 8, 9, 123-126 S
export	10, 124 S
import	11, 124, 125 S
Central Lake mine, Lièvre river, Q., rocks of	99 J
Chaffey iron mine, Crosby township, O., description of	66-69 I
sketch plan of	66 I
Chalk, import of	11, 140 S
Chalmers, R., work by	148-162 A
report by	1-41 M
Channels, post-glacial, of Atlin district, B.C	35 B
Charleston lake, Leeds county, O., occurrence of hæmatite	80 I
Chatham township, Q., limestones of	22 J
Chazy formation in the valley of the Ottawa	84 J
list of fossils	139 J
limestone in the vicinity of Ottawa	29-31 G
photograph of	28 G
analysis of, from Hemlock L.	46 G
lists of fossils	73-75 G
Chelsea, Ottawa county, Q., marine shells near	67 J
Cheney, O., borings at	11 G
Cheputnecticook lakes, N.B., geology of	14 M
Cherty quartzites in Atlin district, B.C	17 B
Chesterville, O., note on peat bog	137 A
Chicamon-stone gold mine, Bull river, B.C., rocks of	99 A
Chickamon-stone claim, Bull river, B.C., erythrite examined	20 R
China, exports to	10 S
Christies Lake iron mine, South Sherbrooke township, O., description of	37-41 I
sketch plan of mine	38 I
microscopic examination of rocks	82 I
Chromite, production	8, 19 S
export	10, 20 S
Chrysocolla from Yukon district, note on	19 R
Chrysotile at Silver lake, Q., note	23 J
Chubbuck and Wilson mica mine Wakefield township, Q	118, 122 J
Churchill River, N.W.T., rocks of	113 A
Clarence, Russell county, Ont., Chazy formation at	85 J
Clarence township, O., Utica shale formation	89 J
Clay deposits between the Ottawa and James bay	11 J
Clays, import of	11 S
north of the Ottawa	12 G, 93 J
examination of	60, 61 R
and sands, north of the Ottawa	91 J
Claystone, examination of	61 R
Clemow and Powell mica mine, Hincks township, Q	127 J
Cliff creek, Yukon district, analysis of lignite	27 R
Climate of Kootenay district, B.C.	102 A
Clinton, Lillooet district, B.C., claystone examined	61 R
Cluscus lakes, Cariboo district, B.C., gold and silver assay	47 R
Coal, production	7, 8, 9 S
production by provinces	21-23 S

	PAGE.
Coal, export	10, 24 S
export by provinces	25, 26 S
import	11, 27 S
consumption	28, 29 S
Nova Scotia, statistics	29-32 S
New Brunswick, statistics	33 S
N.W.T., statistics	33 S
British Columbia, statistics	33-35 S
Collins gulch, Yale district, B.C., description and analysis	29 R
Morley station, Al., description and analysis	30 R
bituminous, note on, in N.B.	157 A
seams, relation of, to red beds, N.S	163 A
Coal tar and pitch, import of	11 S
Coal creek, Yukon district, analyses of lignite	25 R
Coals and lignites, descriptions and analyses of	25-31 R
Cobalt, examination of ore, Kogaluk river	37 R
Masham, Q	37 R
Cobbs lake, O., borings at	11 G
Cocknagog lake, Ottawa county, Q., rocks of	71 J
Coe Hill iron mine, O., note on	129 A
Coe iron mine, Bagot township, O., description of	58-60 I
microscopic examination of rocks	83 I
Coke, production	7-9, 35, 36 S
import	11, 36, 37 S
Colborne township, Huron county, O., analysis of limestone	32 R
Cold lake, Sask., rocks of	111 A
Collection, additions to, mineralogical	192-197 A
palæontological	207 A
zoological	206, 208 A
ethnological	9, 209 A
Collins gulch, Tulameen river, B.C., analysis of coal	29 R
Commandant, Lake, Q., rocks at	37 J
Cone hill, Yukon district, gold and silver assay	44 R
Connors' mine, Hull township, Q., note on mica	40 G
description	125 J
Contact of Chazy limestone with Chazy shales	29 G
of Potsdam with granite	34 G
at Blackwater lake, O	120 A
between limestone and gabbro, Côte St. Pierre	64, 65 O
scapolite and graphite veins, Graphite city	73 O
Contributions to Canadian Palæontology, note on publication	205 A
Copper, production	7, 8, 9, 38, 39 S
export	10, 40 S
import	11, 41, 42 S
ores of McLeod bay, Great Slave lake	108 A
Copper, native, on Goat island, B.C	69 A
Copper, in New Brunswick	149 A
in Atlin district, B.C	46 B
Copperas, import of	11 S
Coppermine river, Great Bear lake, description of country	14 C
Corbeau, Lake, Ottawa county, Q., rocks at	48 J
Correspondence of the department	4, 224 A
Corundum deposits in Ontario	130 A
Coste, E., quoted on the origin of apatite	14 O
Côte St. Pierre, Nation river, Q., rocks at	39 J
deposit of asbestus	106 J
Craig gold mine, township of Tudor, O., note on	129 A
Cranberry beds, on Sable island, origin of	216 A
Cranberry lake, N.B., geology of	13 M
Cranbrook to Wardner, B. C., character of rocks	88 A
to Moyie lake	90, 91 A
to Perry creek	93 A
Cretaceous rocks in northern Alberta	14 A
at Great Bear lake	25 C
Croche, Lac, Ottawa county, Q., rocks at	44, 60 J
Crooked lake, Ottawa county, Q., rocks at	44 J
Cross Creek district, N.B., report of gold	152, 161 A, 41 M
Cross mica mine, Hull township, Q	126 J
Crown Hill apatite mine, Lièvre river, Q., rocks of	97 J
Cryolite, import of	11 S
Crystalline rocks north of Ottawa river, note on	12 J
southern limit of	16 J
in the vicinity of Ottawa	35 G
Crystalline shists from the apatite region north of Ottawa	52-56 O
Culhane iron mine, Bagot township, O., description of	62-64 I
sketch plan and sections	62 I
microscopic examination of rocks	84 I
Cumberland, O., borings at	11 G
Calciferous formation at	83 J
Chazy formation	85 J
Cumberland township, O., Utica shale formation	89 J
Cumberland coal-field, N.S., fossils of	201 A
Cumberland county, N.S., production of coal	31 S
Currie Swan mountain, B.C., metalliferous veins of	69 A
Dalhousie lake, Lanark county, O., occurrence of hæmatite	74 I
Dalhousie iron mine, Lanark county, O., features of	19 I
description of	70-74 I

	PAGE.
Dalhousie lake, Lanark county, O., plan and cross sections.	70 I
Danaite from township of Calumet, Pontiac county, Q., note on	19 R
Danalite from Ungava district, N.E.T., locality and description	15 R
Darling township, O., occurrence of hæmatite	79 I
Datolite from township of Derry, Ottawa county, Q., description and analysis of	17 R
Davidson, W. B. M., quoted on the origin of apatite	15 O
Dawkins, W. B., quoted on the occurrence of apatite	14 O
Dawson, Dr. G. M., report by	1-224 A
quoted on the origin of apatite	14 O
Dawson, J. W., quoted on the occurrence of apatite	12 O
Dawson peaks, Cassiar district, B.C., gold and silver assay	47 R
Dease bay, Great Bear lake, N.W.T., hydromagnesite examined	22 R
occurrence of siderite	24 R
Dease river, Great Bear lake, described	15 C
Delhi claim, Fry creek, B.C., gold and silver assay	46 R
Deloro gold mine, township of Marmora, O.	124-128 A
country rocks of	125 A
character of veins	125, 126 A
Denholm township, Ottawa county, Q., deposit of asbestus.	106 J
Denis, T., work by	3 S
Deposits, relation between inland and marine, in New Brunswick.	31-33 M
fresh-water, of the recent period	33 M
Derry township, Ottawa county, Q., datolite examined	17 R
faujasite examined	18 R
Deschênes, Q., Chazy shales of	31 C
Désert lake, Ottawa county, Q., rocks of	33, 68 J
Désert river, Gatineau river, Q., description and geology of.	68 J
Devil's play ground, Rigaud mountain, Q.	93 J
Devil's river, a tributary of the Rouge, Q.	29 J
Diabase from Great Bear lake, examined	30 C
dykes, in Ottawa county, Q.	53 J
cutting gneiss	57 O
mass of, Marmora township, O.	126 A
character of rocks around	127 A
Diamond gold mine, Madoc, O.	129 A
Diamonds, possible source of, at Hudson Bay	147 A
Dickenson post office, O., occurrence of Medina shale	19 G
Dion creek, Yukon river, gold and silver assay	45 R
Diorite from Great Bear Lake examined	31 C
Discovery claim, Pine creek, B.C., magnesite examined	22 R
Discovery claim, Yukon district, gold and silver assay.	43 R
analysis of water.	60 R
Dog chute, Rouge river, Q., rocks at.	31 J
Dog lake hematite mine, Storrington county, O., sketch section of.	76 I
Dolomites in N.B. examined for use in wood pulp	158, 159 A
township of Ross, Renfrew county, O., description and analysis	35 R
Dominion creek, Yukon, description	41 A
country rocks and gravels	42 A
distribution of gold	43 A
mining	44 A
Dominion creek trail, Yukon, gold and silver assay	43 R
Donaldson graphite mine, Buckingham, Q.	108 J
Dorchester, N.B., building stone of.	201 A
Doré, Lake, Ottawa county, Q., rocks at.	42 J
Dowling, D. B., work by	110-115 A
Drain tiles, import of.	130 S
Dresser, Professor J. A., work by.	10, 138, 139 A
Drury cove, Kennebecasis river, N.B., analysis of limestone	31 R
Dufferin iron mine, Malone, O., note on	129 A
Dufferin mine, Salmon river gold district, N.S.	183 A
workings at	184 A
limit of the veins	184 A
yield of gold	187 A
Dugdale, Yukon district, analysis of anthracite.	30 R
Dunes, sand, Hog's Back, O.	12 G
Dunite (peridotite) of the gold series, Atlin district	20 B
Dunsinane, Kings county, N.B., coal examined	61 R
Dyke rocks near the Lièvre river, Q., character of	97 J
Eagle lake, N.S., note on gold mine	186 A
Eagle point, Spruce creek, B.C., cañon at	41 B
Eagle river, Désert river, Q., description of.	68 J
Earthenware, import of	11, 131 S
East Fork river, West Kootenay, B.C., description of.	78 A
East Kootenay, B.C., work in	87-103 A
region examined	87 A
East Main river, James bay, N. E. T., gold and silver assay.	39 R
Eastman, O., note on mineral springs	137 A

	PAGE.
East Templeton, Q., calciferous formation at	82 J
Echo bay, Great Bear lake, N.W.T., rock examined	32, 33 C
hematite examined	21 R
gold and silver assay	43 R
Economic minerals in the vicinity of Ottawa	37 G, 94 J
in area of Andover and Fredericton sheets, N.B.	40 M
Economy township, Colchester county, N.S., occurrence of mountain leather	24 R
Eel River lakes, N.B., note on	14 M
Egg islands, Bear river, N.W.T., note on	8 C
Eldorado creek, Yukon, character of	37 A
country rocks, gravels and gold contents	38 A
Eldorado reef, Yukon district, gold and silver assay	44 R
Ells, Dr. R. W., work by	131-137 A
reports by	1-77 G, 1-143 J
quoted on the origin of apatite	16 O
Embrun, O., note on quarry in Black River limestone	136 A
Emerald apatite mine, Lièvre river, Q., rocks of	102 J
Emery, import of	11, 15 S
English river, Rainy River district, O., description of	116-121 A
Enstatite-gabbro from Emerald apatite mine, Lièvre R., Q.	39-41 O
microscopic description	40 O
analysis by Dr. Dittrich	40 O
Eozoon Canadense (fig.)	60 O
limestone, Côte St. Pierre	60 O
origin of	66 O
most specimens found at Côte St. Pierre	107 J
Eozoon structure in serpentinous rock, Annunciation, Q	29 J
at Côte St. Pierre, Q.	39 J
Epidote from James bay, N.E.T., note on	20 R
Erratics on the beach of Great Bear lake, N.W.T.	13 C
Eruptive rocks, near apatite veins.	56 O
at Graphite City, Q.	69 O
Eruptives, of West Kootenay district, B.C.	82 A
of Atlin district, B.C.	28-32 B
Eskers in New Brunswick	26, 27 M
Eskimo Seal lake, Hudson bay, description of	141 A
Eskimos at Great Bear lake, N.W.T.	15 C
Etcheminian rocks of Cape Breton Island	189 A
Ethnological collection, additions to	9 A
Eureka creek, Yukon, description	49 A
rocks, gravels and yield of gold.	50 A
Evans creek, West Kootenay, B. C., description of	77 A
Exhibit for Paris Exhibition prepared	5 A
Expenditure	224 A

	PAGE.
Faribault, E. R., work by	168-187 A
Farrels lot, Bathurst township, O., occurrence of magnetite	45 I
Faujasite from township of Derry, Ottawa county, Q., description of	18 R
Faulted tract in Renfrew gold district, N.S.	171 A
in the vicinity of Ottawa	13-16 G
Faults, south of Ottawa, O.	134 A
at Rigaud mountain, Q.	135 A
in the coal seams and red rocks of N.S.	165 A
in Mount Uniacke, N.S.	179 A
in Gloucester township, O.	13 G
north of Tétreauville, Q.	14 G
in Nepean township, O.	14 G
near Ottawa	15, 16, 24, 25 G
in the Ottawa valley	78 J
between Clarence and Rockland, O.	85 J
Fauna, Etcheminian and Cambrian, of Cape Breton Island	189 A
Felspar, production	8, 135 S
export	10 S
import	11 S
occurrence in the vicinity of Ottawa, O.	43 G
north of the Ottawa river	135 J
occurrence with apatite	36 O
Fertilizers, import of	11 S
Field-work, number of explorers employed on	10 A
Fifteen-mile creek, Yukon district, gold and silver assay.	43 R
Fir, Douglas, B.C.	101 A
Fire-clay, production of	8, 135 S
Fisheries on the east coast of Hudson bay	147 A
Five Islands, N.S., rocks of.	167 A
Flagstones, production	8, 122 S
import	122 S
Flat creek, Yukon, description of.	51 A
Fletcher, H., work by	162-168 A
Fleury mica mine, Hull township, Q., note on	124 J
Fluorite, occurrence of, north of Ottawa	38 O
Foley iron mine, Bathurst township O., description of	45 I
Foley barite mine, Hull township, Q., note on	43 G
deposit of barite	134 J
Forests in New Brunswick	37-40 M
suggestions for a provincial park	38 M
Formations along the St. Lawrence river	134 A
Forsythe mine, Hull township, Q.	42 G
note on iron ores	110 J
Fort Confidence, N.W.T., note on	13 C
Fort George, Hudson bay, description of country.	145 A
Fortin and Gravelle's mica mine, Hull township, Q., note on.	124 J
Fossils, Cambro-Silurian in N.B.	161 A
Cambrian of Cape Breton	188 A
Mesozoic, note on publication.	198 A
Trenton, note on publication.	199 A

PAGE.

Fossils, Carboniferous limestones, N.S. and N.B.... ..... 200 A
in Atlin district, B.C..... 18, 25 B
in the vicinity of Ottawa..18, 24, 51-77 G
Four-mile creek, B.C., description of..... 100 A
Fournier iron mine, South Sherbrooke township, O., description of mine..... 34-36 I
sketch plan of mine..... 34 I
microscopic examination of rocks 84 I
Fredericton quarter-sheet map, surface geology of. ..... 1-41 M
See New Brunswick.
Fruit in Kootenay district, B.C., note on ..... 102 A
in Atlin district, B.C..... 12 B
Fuller's earth, import of ..... 11 S

Gabbros examined microscopically 21 O
from the smithy at Emerald mine 41 O
from South March, O..... 43 O
mica-hypersthene gabbro..... 63 O
hypersthene biotite gabbro ... 69 O
Galena at Richmond gulf, Hudson bay..... ..... 143 A
in township of Bedford, Frontenac county, O., note on. 20 R
Galena and blende, Great Slave Lake..... 109 A
Game in Atlin district, B.C..... 13 B
Garnet-sillimanite-gneiss from Poupore post office, Q..... 53 O
Gatineau river, Q., limestones east of the.. .. .. 36, 37 G
country along the upper ..... 10 J
sandy plains..... 11 J
geology of.. .... 61-71 J
Gatineau and Lièvre rivers, Q., geology of the area between 59 J
Gemmill mica mine, Hull township, Q ..... 38 G, 121 J
Gens de Terre river, Gatineau river, Q., description..... 70 J
Geology, economic, West Kootenay, B.C..... 85 A
Germany, exports to..... 10 S
Giant claim, Trail creek, B.C., occurrence of molybdenite. 23 R
Girard, lake mica mine, Wakefield township, Q..... 119 J
Glacial deposits, Atlin district, B.C..... .. . 73 A
in New Brunswick.... ..... 26 M
Glacial striation in the vicinity of Ottawa..... 18 G
of New Brunswick..... 17 M
Glaciation, West Kootenay, B.C. 84 A
Atlin district, B.C. ..... 13 B
and shore-lines, Great Slave Lake..... 109 A
Rainy River district.. ..... 120 A
New Brunswick..... ... 17, 28 M
Gladys lake, B.C., size of..... 59 A
rocks of..... 60 A
streams entering..... 60 A

PAGE.

Gladys river, Atlin district, B.C., description of .... 9 B
Glamorgan, township of, O., rocks of ..... 124 A
Glendale, Inverness county, N.S., graphite examined ..... 62 R
Glendower iron mine, Bedford township, Frontenac county, O..... 20-28 I
geological features..... 20, 21 I
description of pits ..... 22, 23 I
diamond drill borings..... 24, 25 I
magnetic readings..... .. .. 25 I
ore shipments ..... 26 I
history of the mine ..... . 26 I
microscopic examination of rocks..... ... 86 I
Glen Robertson, Glengary county, O., note on rocks .... 79 J
note on quarries..... .. . 135 A
Gloucester township, Carleton county, O., analysis of limestone .... 32 R
Gmelinite from West Kootenay district, B.C., note on .... 21 R
Gneiss, garnetiferous, West Kootenay, B.C. ..... 81 A
fundamental, employment of term..... ..... 16 J
specimen from Montebello, Q. 3-8 O
specimen from Lachute, Q .... 8, 9 O
of eruptive origin.... ..... 9 O
from Trembling mountain and Lakefield, Q..... 10 O
cut by a dyke .... 11 O
Gneisses from the neighbourhood of Ottawa..... 3-11 O
macroscopic description..... 4 O
feldspar and mica constituents. 4 O
typical hornfels structure ..... 5 O
analyses compared..... 5 O
of sedimentary origin..... 7 O
and granites along the K. & P. railway.. ... . 10, 11 I
Goat island, B.C., discovery of copper .... 69 A
Gold, production..... 7, 8, 9, 97-108 S
export..... 10 S
mining, Atlin district, B.C.... 1-48 B
discovery of gold ..... 6 B
rocks of gold series..... ... 18-21 B
origin and output of placer gold .... 34 B
amount produced..... 44 B
free milling gold quartz..... 45 B
in gravels, Yukon district... 27 A
methods of working..... 28-30 A
amount produced ..... 30 A
alluvial, in New Brunswick..... ... 150-152 A, 41 M
bearing gravels..... 150, 151 A
placers, where found.... ..... 151 A
conclusions and source of the gold... ..... . 151, 152 A
bearing rocks, Hants county, N.S. .... 169 A
Gold Series, rocks of, in Atlin district, B.C ..... 18-21 B
application of term ..... 18 B

	PAGE.
Gold series, age of rocks	19 B
characteristic rocks	19, 20 B
distribution	20, 21 B
origin of	34 B
Gold creek, B.C., charactor of rocks	89, 90 A
Gold Run creek, Atlin district, B.C., description	36 B
Gold Run creek, Yukon, description of	48 A
country-rocks, gravels, and distribution of	48 A
Gordon, C.H., paper on syenite gneiss referred to	79 O
Gore road, west, Argenteuil county, Q., rocks along	19 J
east road	21 J
Grand Manitoulin island, O., celestite examined	19 R
Grand River barrens, Richmond county, N.S., analysis of limonite	36 R
Granite production	8, 120 S
from Lake Rosamond, N.W.T., examined	31 C
porphyry, Atlin district, B.C., composition of	29 B
from Lake Ste. Croix, N.W.T., examined	36 C
quarry, Grenville, Q	138 J
belts of New Brunswick	7, 37 M
denudation of	16 M
Granites, Yukon district	21 A
Nelson, West Kootenay, B.C.	81 A
note on specimens sent to Paris	158 A
of Atlin district, B.C.	26 B
Granite creek, Tulameen river, B.C., clay examined	61 R
Granite mountains, B.C	59 A
Grant, Lake, Camsell river, N.W.T., description of	22 C
Graphite, production	8, 46 S
import	11, 46 S
export	47 S
two Canadian occurrences of	66-82 O
township of Buckingham, Q.	66-73 O
township of Grenville, Q.	73-82 O
occurs as filling of veins	67 O
contract of veins	68 O
mode of occurrence	74 O
analysis by Hoffmann	77 O
further discoveries probable	78 O
origin of, in granular limestone	79 O
from township of Bedford, Frontenac county, O., note on	21 R
from township of South Cananto, Frontenac county, O.	21 R
examination of	62 R
of Babiche rapid, Lièvre river	57 J
deposits of Ottawa district	107-110 J
Graphite City, Buckingham township, Q., on the occurrence of graphite	66-73 O
Graphitic limestones, Argenteuil county, Q.	19, 21 J
Gravels, in Yukon district, classification of	23-27 A
Gravels and silts, Kootenay district, B.C.	101 A
pre-glacial, of Atlin district, B.C.	32-34 B
Great Bear Lake, district examined	5 C
character of investigation	5 C
best route to	5 C
geology of	24-27 C
minerals	27 C
glaciation	27 C
examination of rocks	29-36 C
Great Britain, exports to	10 S
Great Slave lake, rocks of	106, 107 A
glaciation and shore lines	109 A
Great Whale river, Ungava, journey up	141 A
rocks along	142 A
gold and silver assay	39 R
Green lake, Ottawa county, Q., rocks at	30, 42 J
Greens creek, near Ottawa, O., fault at	15 G
fossils at	17, 91 G
Chazy shales	31 G
limestone formation	86 J
Greenstone in Atlin district, B.C., description and distribution	22 B
at Great Bear lake, N. W. T.	26 C
area, West Kootenay, B.C.	82 A
Grenville canal, Q., Chazy formation at	84 J
Grenville series, note on	122 A
employment of term	16 J
newer than the fundamental gneiss	75 J
Grenville township, Q., limestones of	22 J
road to Lost river	23 J
occurrence of graphite	73-82 O
graphite of	109 J
mica mines	111, 113 J
iron ores	111 J
ochres	136 J
deposits of peat	137 J
occurrence of rensselaerite	138 J
granite quarries	138 J
Grindstones, production	8, 12 S
export	10, 12, 13 S
import	11, 13 S
Grossularite, from Yukon district, locality, description and analysis	14, 15 R
Grouard, Lac, Camsell river, N.W.T., note on	19 C
Guay mica mine, Wright township, Q.	127 J
Gwillim, J. C., reports by	52-103 A, 1-48 B
Gypsum, production	7, 8, 9, 48, 49 S
export	10, 50 S
import	11, 51 S
specimens sent to Paris	160 A
deposits of the Tobique valley, N. B., note on	40 M

PAGE.

Hæmatite from Great Bear lake, N. W. T. ..... 21 R
deposits along the K. & P. railway ..... 18, 19, 69-80 I
character of deposits ..... 18, 19 I
Dalhousie and McNab mines .. 19 I
mode of occurrence ..... 69, 70 I
analyses of ore ..... 93 I
from Antigonish county, N. S., analysis of ..... 35 R
from Great Bear lake, N.W.T. 36 R
Great Slave lake, N.W.T. ..... 36 R
examination of ..... 62 R
Haliburton, O., map-sheet, work done ..... 122-123 A
Halycites catenularia from Mount Charles, N.W.T. ..... 29 C
Hammond, O., borings at ..... 11 G
Hants county, N.S., gold-bearing rocks of ..... 169 A
Hareskin and Dogrib Indians, note on ..... 10 C
Harrington, Dr., paper by ..... 9 J
quoted on the occurrence of apatite ..... 13 O
Harrington township, Argenteuil county, Q., limestones of .. 26 J
Harvey township, O., rocks of ... 123 A
Hawaii, exports to ..... 10 S
Hawkesbury, Prescott county, O., Calciferous formation near 83 J
Chazy formation ..... 84 J
Hawkesbury West township, O., Utica shale formation ..... 89 J
Haycock mine, Hull township, Q., note on iron ore ..... 43G, 110 J
note on mica ..... 125 J
Hay Cove, Richmond county, N.S., shale examined ..... 63 R
Hematite. *See* Hæmatite.
Hemlock lake, Ottawa, O., Chazy limestone of ..... 46 G
shell marl of ..... 47 G
list of fossils ..... 56 G
Hibou creek, Eagle river, Q., description of ..... 68 J
High falls, Lièvre river, Q., description and geology ..... 53, 55 J
High Falls apatite mine, Lièvre river, Q., rocks of ..... 99 J
High Rock apatite mine, Lièvre river, Q., rocks of ..... 98 J
Hincks mica mine, Aylwin township, Q., note on the mica. 66 J
Hincks township, Q., mica mines in .. .. 127, 133 J
Hoffman, Dr, G. C., reports by ..... 189-197A, 1-64 R
paper by ..... 9 J
Hog's Back, Ottawa, O., limestones of ..... 28, 30 G
Holland, exports to .. .. 10 S
Hong Kong, exports to ..... 10 S
Hope, Cape, Hudson bay, rocks of ..... 146 A
Hornfels structure, typical 50
Horse-shoe mica mine, Hull township, Q ..... 117 J

PAGE.

Hottah, Lake, N.W.T., description of ..... 20 C
rocks examined ..... 34 C
Howse iron mine, Bedford township, O., note on ..... 28 I
Huckleberry chute, Rouge river, Q., rocks at .... 31 J
Hudson bay, explorations on .... 139-148 A
results of the work ..... 147 A
fisheries ..... 147 A
Hughes and Haldane mica mines, Wakefield township, Q .... 117 J
Hull township, Ottawa county, Q., geology of 72-76J
limestone bands in ..... 36 G
mica mines in .... 38, 39G, 131, 132 J
occurrence of rensselaerite. ... 138 J
Hunker creek, Yukon, description and country rocks .... 39 A
gravels and quartz-drift ..... 40 A
gold contents .... 41 A
Hunker series, Yukon district .. 19 A
Hunt, Dr. Sterry, paper by ..... 9 J
quoted on the occurrence of apatite ..... 12 O
Huntley township, Carleton county, O., barite examined ... 19 R
Huronian rocks, Great Slave lake 106 A
Saskatchewan ..... 111 A
File lake, N.W.T. ..... 113 A
Hydromagnesite, occurrence in British Columbia ..... 190 A
Great Bear lake, N.W.T. ..... 22 R
Hydronephelite from Ice river, Rocky mountains, B.C., description and analysis ... 13 R
Hypersthene biotite gabbro, Graphite city, described ..... 69 O

Ice movements in the basin of the Ottawa ..... 94 J
Ice river, B.C., description and analysis of schorlomite .... 12 R
analysis of hydronephelite ... 13 R
Idocrase, Wentworth township, Q .... 23 J
Igneous rocks of Shefford mountain, Q ..... 138 A
of the gold series ..... 19 B
their association with economic minerals ..... 95 J
Iles, Lac des, Ottawa county, Q., rocks at. ..... 44 J
Indian river, Yukon, N.W.T., yield of gold ..... 51 A
gold assay ..... 43, 45 R
Indian River series, Yukon district ..... 18 A
Indians, Hareskin and Dogrib, N.W.T ..... 10 C
Infusorial earth in New Brunswick, note on ..... 159 A
Ingall, E. D., reports by .... 197 A, 1-91 I, 1-144 S
survey by .... 9 J
Intervales along the St. John river, N.B ..... 33 M

PAGE.

Invertebrata, report on marine.. 199 A
Iron, production of ore..... 7-9, 52-54 S
export of ore ... . 10, 55 S
exports of iron and steel goods. 10, 59 S
imports .....11, 60-70 S
pig, production of.... ..... 56-59 S
Iron ore on the coast of Hudson Bay .... 147 A
found at Great Bear lake.... 27 C
found in New Brunswick ..... 156 A
in the Hull township, Q ..... 42 A
along the K. & P. railway .... 1-91 I
See 'Kingston.'
development in the Ottawa district ..... 110, 111 J
from Antigonish county, N.S., description and analysis of. 35 R
from Great Bear lake, N.W.T., description and analysis. 36 R
from Great Slave lake, N.W.T. 36 R
from Grand River falls, Richmond county, N.S.... 36 R
from Cape Breton county, N.S. 36 R
specular, Great Bear lake..... 21 R
Yukon district .... 21 R
Lewis river, examination of . 64 R
Isabella, Lake, N.W.T., note on. 21 C

Jamesonite from Yale district, B.C., note on ..... 22 R
Jannasch, Prof., examination of inclusions in mica by .. .. 33 O
Jasper, Hull township, Q..... . . 39 G
Jennings river, B.C., note on.... 61 A
Johnston, R.A.A., work by. 191 A, 1-64 R
Jones, Cape, Hudson bay, description of country .... 145 A
Jones island, Ottawa river, rocks of..... .... 17 J

Kames in New Brunswick..... 27 M
Kaolin deposits, Amherst township, Ottawa county, Q.... 135 J
Kaslo, West Kootenay, B.C., gold and silver assay..... 47 R
Katherine, Hastings county, O., note on lead, zinc and silver mine... . . . . 130 A
Katseyedie river, Great Bear lake, note on name..... 13 C
Keewatin rocks, note on..... 7 A
Rainy River district, O..116, 118, 119 A
Keith bay, Great Bear lake, note on..... ..... 10 C
physiography of country..... 10 C
Kendall lake, Buckingham township, Q., occurrence of mica 113 J
Keswick river, N.B., geology of. 13 M
Kettle river, Yale district, B.C., occurrence of jamesonite.. 22 R
Kidney lake, Ottawa county, Q., rocks of..... 35 J
Kidston, R., report by.....201.202 A
Kinahan, G. H., quoted on the occurrence of apatite..... 14 O

PAGE.

Kingsmere, Hull township, Q., mica mines at .... 38, 39 G
Kings mountain, near Chelsea, Q., crystalline rocks of..... 35 G
Kingston and Pembroke Railway, iron ore deposits along the. 1-91 I
scope and charactor of investigations made..... 5 I
places visited..... 6 I
transportation facilities..... 7 I
supply of water and timber.... 8 I
surface and geological features. 8, 9 I
gneisses and granites . ..... 10, 11 I
magnetite deposits.....12-18, 20-69 I
hæmatite deposits.....18, 19, 69-80 I
bog ores..... 20 I
general conclusions..... 20 I
analyses of iron ores..... 93 I
Kinongé river, Ottawa county, Q., rocks at..... 37 J
Kirks Ferry, Hull township, Q., mica mines at ..... 40 G
Klondike region, geography of.. 16 A
topography of..... 16-18 A
geology of..... 18-27 A
gold in gravels ..... 27, 28 A
methods of working..... 18-30 A
description of creeks..... 30-52 A
Klondike river described ..... 17 A
Knife Hill, Great Bear lake, view from .... 12 C
Kogaluk river, Hudson bay, pyrrhotite..... 27 R
gold and silver assay. ..... 40 R
Kootenay. *See* West *and* East Kootenay.
Kootenay river, B.C., character of rocks east of..... 98 A
Kootenay valley, B.C., description of..... ..... 87 A
Kyuquot, Vancouver island, B. C., pyrrhotite examined... 38 R

Labelle, Q., rocks in the vicinity. 27 J
Lachute, Argenteuil county, Q., rocks at..... 17 J
outcrops north of ..... 18 J
road to St. Jérôme..... 21 J
road to Lakefield..... 21 J
Potsdam formation..... 79 J
Calciferous formation.. . . .. 82 J
note on quarries..... 136 J
examination of gneiss..... 8, 9 O
Lagoon, on Sable island..... 214 A
Lake township, O., rocks of..... 123 A
Lake View mountains, B.C., rocks of..... 70 A
Lambe, L. M., work by ..... 205 A
Larch, western, B.C.,..... 101 A
Lathyrus maritimus, on Sable island ..... 215 A
Laurentian rocks, Great Slave Lake.... .....106, 107 A
early views as to the structure of..... 15 J
supposed thickness of..... 15 J

	PAGE.
Laurin's mica mine, Templeton township, Q.	120 J
Lavant township, Renfrew county, O., mines of	46-54 I
Leach, W. W., work by	75 A
Lead, production	7, 8, 9, 71, 72 S
export	10, 73 S
import	11, 74-76 S
mines in Haliburton county, O, note on	130 A
Leaf river, Ungava Bay, note on	141 A
Leda arctica found near Cantley and McGregor lake, Q.	92 J
Ledyard gold mine, township of Belmont, O	128 A
Leopard rock, structure of, Grenville, Q.	81 O
Lepidolite from Wakefield township, Ottawa county, Q.	11 R
analysis	12 R
LeRoy, O. E., examination of rock by	17 B
Les Iles du Large, Great Slave lake, N.W.T., hematite examined	21 R
analysis of hematite	36 R
Lethbridge, Al., examination of shale	64 R
Lewes river, Yukon district, analysis of lignitic coal	28 R
Library, report on	223 A
Lièvre river, Ottawa county, Q., description and geology of	53-59 J
length, and description of falls	53 J
mining areas	54 J
rocks in the vicinity	55-59 J
country along the upper	10 J
Lièvre and Gatineau rivers, Q., geology of the area between	59-67 J
route between the rivers	59 J
Lièvre and Nation rivers, Q., geology of the area between	47-53 J
Lignite from Coal creek, Klondike, N.W.T., description and analysis of	26 R
from Cliff creek, Yukon	20 A, 27 R
Lignitic coal from Lewes river, Yukon district, description and analysis of	28 R
Lime, production	7, 8, 126 S
export	10, 126 S
import	11, 127 S
Limestone, for flux, statistics	8 S
quarries, in the vicinity of Ottawa	45 G
See Black river, Chazy Trenton	
Limestones, south of Wardner, B.C., description of	88 A
near Cranbrook, B.C.	95 A
note on specimens sent to Paris	158 A
Atlin district, B.C.	16 B
township of Wakefield, Q.	72 J
from Hull, Q., analysis of	45 G
Kennebecasis river, N.B., description and analysis of	31 R
township of Gloucester, Carleton county, O., description and analysis	32, 33 R
Limestones, township of Colborne, Huron county, O., description and analysis	33, 34 R
and dolomites, sent in for examination	31-35 R
Limonite from Grand River falls, Richmond county, N.S., analysis	36 R
Litchfield township, Pontiac county, Q., magnetite examined	63 R
Literature on the Archæan rocks of the Ottawa valley	82-84 O
Litharge, import of	11, 75 S
Lithographic stone, production	8 S
import	11 S
Little Atlin lake, Atlin district, B.C., description of	56 A, 7 B
Little Edna mountain, B.C., quartz vein of	70 A
Little Edna gold vein of Birch creek, B.C., note on	45 B
Little Nominingue lake, Ottawa county, Q., rocks of	33 J
Little Rapids apatite mine, Lièvre river, Q., rocks of	101, 112 J
note on amphibole	37 O
Little Rideau river, Prescott county, O., Chazy formation along	84 J
Little Slocan river, West Kootenay, B.C., description of	78 A
Little Stag lake, Ottawa county, Q., rocks at	50 J
Llewellyn glacier, Atlin district, B.C, description of	15 B
Lochaber township, Ottawa county, Q., rocks of	51 J
occurrence of graphite	109 J
Lode mining in Atlin district, B.C.	44 B
Logan, W. E., report of, for 1853-56	15 J
London apatite mine, Lièvre river, Q., rocks of	101 J
peculiar crystalline schists	54 O
Long island, Lièvre river, Q., rocks at	57 J
Long lake, Maskinongé river, Q., rocks at	35 J
Long lake, Nation river, Q., rocks at	45, 46 J
L'Orignal, Prescott county, O., Chazy formation at	84 J
note on quarries	136 J
L'Orignal, rapid, Lièvre river, Q., rocks at	58 J
Lorraine formation in the vicinity of Ottawa	19 G
list of fossils	57 G
south of Ottawa	78 J
Lost river, Argenteuil county, Q., rocks at	22 J
note on name	25 J
a tributary of the Rouge	29 J
Louisa, Lake, Wentworth township, Q., limestones of	22 J
Louisbourg, Cape Breton county, N.S., clay examined	60 R

PAGE.

Low, A. P., work by ..... 139-148 A
Lowe, James, work done by... . 7 J
Lower Arrow lake, B.C., character of country west of..... 79 A
Lower Long lake, Nation river, Q., rocks at..... 46 J
Lubbock river, Atlin district, B.C., description of..... 9 B
Lupinus arcticus at Fort Confidence, N.W.T..... 14 C

Maberly properties, South Sherbrooke township, O., note on iron ore..... 44 I
Macaza river and its branches, Q., rocks of..... 28 J
Macfarlane's mica mine, Hull township, Q..... 126 J
Mackenzie district, work in....103-110 A
previous surveys..... 105 A
rocks and ores of Great Slave lake .....106-108 A
Macoma fragilis found near Cantley and McGregor lake, Q. 92 J
MacRae apatite mine, Templeton township, Q..... 20 O
MacTavish bay, Great Bear lake, description of ..... 16, 17 C
Macoun, Prof. J., work by..... 209 A
Macoun, J. M., work by..... 210 A
Magaguadavic lakes, N.B., geology of ..... 14 M
Magnesite of Atlin district, B.C.71 A, 21 B
description and analysis.....72 A, 21 B
deposits along the K. & P. railway.....12-18, 20-69 I
use of magnetic needle..... 12 I
character of deposits..... 13 I
size of ore-bodies..... 14 I
character of ores..... 15 I
chemical constitution..... 16 I
analyses of ore..... 93 I
note on specimen from Yukon district, N.W.T..... 22 R
from Cape Breton county, N.S., analysis of..... 36 R
examinations of..... 63 R
Magnetic separator, note on..... 44 B
Malchite dyke rocks, Côte St. Pierre, Q..... 64 O
Malfait, Lac, N.W.T., description of.. ..... 20 C
Mallotus in clay nodules along the Ottawa river..... 91 J
Manganese ore, production..... 8, 77 S
import..... 11, 79 S
export..... 78 S
specimens sent to Paris..... 156 A
Manitoba, mineral production of. 8 S
Manson creek, Cassiar district, B.C., gold and silver assay. 47 R
Maps published in 1899... ..... 221 A
in preparation..... 221, 222 A
Marble, production..... ..... 8, 119 S
import.....11, 119 S
Marble falls, Rouge river, Q., rocks at..... 26 J

PAGE.

March township, Carleton county, O., occurrence of felspar .. 44 G
Marian river and lake, N.W.T., note on..... 24 C
Marine clays of the Ottawa valley. 90 J
Marine fossils of Green creek, Ottawa river ..... 17 G
Odell's brickyard, Ottawa..... 17 G
at other places near Ottawa.... 17 G
Marine shells in Nepean township, O..... 12 G
near Chelsea, Q..... .. 67, 92 J
Maringouins, Lac des, Great Bear lake, description of ..... 11 C
Marl, occurrences in Argenteuil county, Q..... 137 J
along the Gatineau river.. ... 138 J
in Renfrew county, O..... 23 R
shell, Hemlock lake, analysis.. 47 G
in Argenteuil county, Q..... 137 J
Martel iron mine, Bagot township, O., description of.... 61 I
microscopic examination of rocks..... 88 I
Mary iron mine, Palmerston township, O., description of..... 29-32 I
sketch plan of..... 30 I
Masham, township of, Ottawa county, Q., pyrite examined. 37 R
Maskinongé lake, Ottawa county, Q., geology of and dimensions..... 35 J
Maskinongé river, Ottawa county, Q., rocks of..... 34 J
Matawatchan, township of, Renfrew county, O., pyrrhotite examined..... 37 R
Matthew, Dr. G. F., work by.10,187-189A
Matthews iron mine, Crosby township, O., description of 66-69 I
sketch plan of..... 66 I
McConnell, R. G., report by .... 16-52 A
McEvoy, J., work by..... 87-103 A
McGregor lake, Ottawa county, Q., marine shells at..... 92 J
note on mica..... 121 J
McInnes, W. work by.....115-131 A
McIntosh apatite mine, Templeton township, Q., rocks of. 103 J
McKee creek, Atlin district, B.C., description, and rocks.. 66A, 44 B
mineral water of..... 72 A
McLeish, J., work by..... 3 S
McLeod, Colin, work by..... 162 A
McLeod, M. H., work by..... 162 A
McLeod bay, Great Slave lake, rocks of... ..... 108 A
McMaster mountain, Atlin district, B.C., situation and description..... 27 B
McNab iron mine, Renfrew county, O., features of.... 19 I
McNaughton graphite mine, Buckingham, Q..... 108 J
McRae's apatite mine, Templeton township, Q., note on.... 41 G
rocks of. ..... 103 J
McRae's mica mine, Wakefield lake, Q..... 120 J

	PAGE.
Meach lake, Hull township, Q., rocks of	37 G
Meander river, N. S., alluvial deposits of gold	182 A
Medina, shales of Osgoode, O.	19 G
south of the Ottawa	78 J
Mer Bleue peat bog, O., note on	12 G
Mercury, production	8, 79 S
import	11, 80 S
Merrickville, O., note on peat bog	137 A
Mesozoic rocks of Atlin district, B.C.	16 B
Methuen, township of, O., rocks of	123 A
Mexico, exports to	10 S
Mica, production	8, 80 S
export	10, 81 S
deposits in the vicinity of Ottawa	37-41 G
in Haliburton county, O	129 A
in Ottawa and Argenteuil counties, Q	111-134 J
varieties of	112 J
modes of occurrence	115 J
mines in Hull township	121-126 J
mines in Templeton township	129-131 J
occurrence of, north of Ottawa	11 O
examined for fluorine and lithium	29 O
inclusions in	31-33 O
Mica-hypersthene-gabbro, why so called	63 O
Micaceous hematite from Great Bear lake, N.W.T., note on	21 R
Michel creek, East Kootenay, B.C., clay examined	61 R
Microscopic examinations of rocks, K. & P. railway	81-91 I
Mineral industry of Canada	7-11 S
Mineral pigments, imports	11, 81-83 S
production	82 S
Mineral springs in Ontario	137 A
Mineral statistics	197, 198 A
statistics and mines	5-144 S
Mineral waters, production	8, 85 S
export	10 S
import	11, 85 S
of Atlin district, B.C.	71 A
in the vicinity of Ottawa, O.	48 G
Mineralogical collection, contributions to	192-197 A
from N.B., for Paris exhibition	155 A
collections for educational institutions	196 A
Minerals and ores inquired for	5 A
description of	11-25 R
Minerals, economic, vicinity of Ottawa	37 G, 94 J
New Brunswick	40, 41 M
Minto, Mount, Atlin district, B.C., description of	55 A, 14 B
Mississippi iron mine, Palmerston township, O., description of	29-32 I
sketch plan of mine	30 I
Molybdenite, statistics	8 S
from township of Brougham, Renfrew county, O.	23 R
from James bay, N.E.T	23 R
Molybdenite, West Kootenay district, B.C.	23 R
Monazite from township of Villeneuve, Ottawa county, Q., note on	24 R
Monmouth, township of, O., rocks of	124 A
Montebello, Q., gneiss from	3, 7 O
quartzite from	7 O
Montreal road, Ottawa, borings near	10 G
contact of Utica shale with Trenton limestone	23 G
Monument Settlement, York county, N.B., ferruginous shale examined	64 R
Moore creek, B.C., copper deposits	69 A
Moose Hide group, Yukon district	19, 20 A
Mooseskin mountain, Yukon district, gold and silver assay	45 R
Moraines in Atlin district, B.C.	15 B
in New Brunswick	26 M
Morin township, Q., rocks of	19 J
rock formation	20 J
Morrow iron mine, South Sherbrooke township, O., description of	43 I
Moulding sand, production of	8, 136 S
Mount Charles, near Great Bear lake, description of	8 C
Mount Dominion, Yukon district, gold and silver assay	46 R
Mount Uniacke gold district	175-179 A
plan and veins	175 A
Nuggetty lead	176 A
auriferous veins	177 A
good prospects for deep mining	178 A
yield of gold	179 A
Mountain leather from Colchester county, N.S., note on	24 R
Mountain portage, Gatineau river, Q., rocks at	69 J
Moyie lake, B.C., character of rocks	91 A
Moyie river, B.C., description and rocks	91 A
Mulgrave township, Ottawa county, Q., rocks in	52 J
Museum, necessity for new	8 A
national, advocated by Sir W. Logan	8 A
B. E. Walker quoted	9 A
Nacawicac river, N.B., geology of	13 M
Nakina river, Atlin district, B.C., description of	9 B
Narakay islands, Great Bear lake, description of	16 C
Nashwaak district, N.B., report of gold	152 A
Nation river, Prescott county, O., boring on	11 G
Nation and Lièvre rivers, Q., geology of the district between	47-53 J

	PAGE.
Nation and Rouge rivers, Q., geology of the area between	32-46 J
colonization roads	32 J
Natron, occurrence in British Columbia	190 A
Natural gas, production	7, 8, 9, 86 S
Navan, O., contact of Utica shale with Trenton limestone	23 G
Nellie and Blanche mica mine, Hull township, Q	38 G, 123 J
Nelson House, N.W.T., vegetation of	112 A
Nepean township, Carleton county, O., Potsdam of	34 G
Newberyite from Yukon district, N.W.T., where found, description and analysis	13, 14 R
New Brunswick, surface geology of Fredericton and Andover ¼-sheet maps	148-155 A, 1-41 M
special points investigated	148 A
former investigations	5 M
character of investigations	5 M
physiography	153 A, 6-8 M
rivers and lakes	8-15 M
changes of level	15 M
denudation	16 M
glacial striation	17 M
list of striae	17-26 M
boulder-clay, moraines, etc	26 M
eskers, kames, etc	27 M
remarks of glaciation	28 M
modified inland deposits	29 M
river and lake terraces	30 M
relation between inland and marine deposits	31-33 M
fresh-water deposits	33 M
peat bogs	34 M
agricultural capabilities	154 A, 34-37 M
forests	37-40 M
economic minerals	40, 41 M
occurrence of gold	150-152 A
specimens of minerals for Paris exhibition	155 A
mineral production	8 S
production of coal	33 S
New Edinburgh, Ottawa, area of Utica shale	22 G
Newfoundland, exports to	10 S
Newington, O., note on peat bog	137 A
New York and Ottawa railway, elevations in vicinity of Ottawa	7-9 G
Niagara limestone at Reed lake, Sask	113, 114 A
Nickel, production	7, 8, 9, 87, 88 S
export	10, 87 S
import	11, 89 S
from N.B	156 A
and cobalt, examination of ore	37, 38 R
from Hudson bay, N.E.T	37 R
Renfrew county, O	37 R
Texada island, B.C	37 R
Vancouver island, B.C	38 R
Oattwa county, Q	37 R
Nigger creek, B.C., rocks of	92 A
Nitrate of soda, import of	11 S
Nodules, clay, Ottawa river	91 J
Nomininge creek, a tributary of the Rouge, Q	29 J
Nominingue lakes, Ottawa county, Q., rocks at	29 J
North American Graphite Co., note on mine in Buckingham township, Q	109 J
North and Rouge rivers, Q., geology of, district between	17-32 J
North Nation Mills, Ottawa county, Q., rocks at	40 J
North Star gold mine, Kimberly, B.C., note on	95 A
North Star apatite mine, Lièvre river, Q., rocks of	100 J
Northfield township, Q., occurrence of mica	133 J
Northumberland county, N.B., list of striæ	23 M
Nova Scotia, work in	162 A
gold districts of	168-187 A
Renfrew gold district	169-175 A
Mount Uniacke, gold district	175-179 A
South Uniacke, gold district	179-180 A
Upper Newport, gold district	181 A
Meander River gold district	182 A
Ardoise gold district	182 A
Dufferin mine, Salmon river	183 A
Lake Eagle gold mine	186 A
yield of gold	187 A
mineral production	8 S
production of coal	29-32 S
of copper	42, 43 S
of iron	53, 54 S
export of iron	55, 59 S
production of gold	99-102 S
North-west Territories, mineral production of	8 S
production of coal	33 S
of gold	104 S
Nuphar advena (?) found in Great Bear lake	11 C
Ochres, production	8, 82 S
import	82 S
of Grenville, Q	136 J
O'Donnel river, Atlin district, B.C., description of	10 B
Oil refined, export	10 S
Old Chelsea, Hull township, Q., rocks at	39 G
Old Feigle gold mine, Malone, O., note on	128 A
Old French road, Cape Breton county, N.S., magnetite examined	36 R
Ontario, work in	115 A
mineral production	8 S
production of copper	43 S
iron	53, 54 S
export of iron	55, 59 S
production of gold	103 S
Ord, L. R., work of	6 J
exploration by	8 J
quoted	48, 58, 63, 68 J
Orignal, L', rapid, Lièvre river, Q., rocks at	58 J

PAGE.

Oromocto lake, N.B., geology of. 13 M
Osann, Professor A., work by...10, 132 A
report by..... 1-84 O
Osars in New Brunswick..... 27 M
Ottawa city and vicinity of, geology of.....132 A, 1-77 G
compilation of map..... 5, 6 G
formations represented..... 5 G
railway lines ..... 6 G
lists of fossils..... 51-77 G
Ottawa county, Q., geology of... 1-143 J
See Argenteuil.
Ottawa river, formations along.. 6, 7 J
character of county north of... 9, 16 J
upper, work on..... 132 A
lower, report on..... 143 J
Ottawa valley, sedimentary deposits in..... 76 79 J
Archæan rocks of ..... 1-84 O
Otter creek, Atlin district, B. C., gold mining at.....63 A, 43 B

Pagutchi lake, Rainy River district, O., description and rocks..... 118 A
Paint Hills, Hudson bay, rocks of..... 145 A
Paint Hills islands, James bay, N. E. T., amazonstone examined .. .. 19 R
molybdenite examined. ..... 23 R
gold and silver assay..... 41 R
Palæontological work..... 198 A
collection, additions to..... 206 A
Palæontology, Contributions to Canadian, printing of..... 205 A
Palæozoic formations in the vicinity of Ottawa..... 5 G
of the Ottawa valley..... 76 J
rocks of Atlin district, B.C ... 16 B
Palmer Bar creek, B.C., note on gold diggings..... 92 A
rocks of..... 94 A
Palmerston township, Frontenac county, O., description of mines..... 29-32 I
sketch plan of mines..... 30 I
Papaver arctica at Fort Confidence, N.W.T ..... 14 C
Papineauville, Ottawa county, Q., rocks at..... 39 J
note on quarry east of..... 80 J
calciferous formation..... 82 J
occurrence of felspar..... 135 J
Paraffine candles, import of..... 11 S
Paraffine wax, import of..... 11 S
Pay Roll claim, Little Nigger creek, B.C., altaite examined..... 19 R
Peat bogs south of Ottawa, O... 137 A
in New Brunswick..... 34 M
Peat deposits of Grenville township, Q..... 137 J
Pegmatites in the basin of the Ottawa..... 95, 116 J
cut by apatite veins..... 22 O

PAGE.

Pelican River, Alta., equivalency of Cretaceous rocks..... 14 A
Pemichangan lake, Ottawa county, Q., rocks at..... 63 J
Pendleton, O., borings at..... 11 G
Penrose, R.A.F., quoted concerning the pyroxenites..... 15 O
Perkins Mills, Templeton township, Q., apatite-bearing rocks of..... 102 J
note on mica..... 128 J
Perry creek, B.C., character of rocks..... 93 A
Petroleum, production..... 7, 8, 9, 90 S
import..... 11, 93 S
export..... 92 S
prices..... 95 S
Phlogopite accompanying apatite 29 O
analysis of..... 30 O
Phosphate, production..... 8, 96 S
export..... 10, 96 S
import..... 11 S
Phosphorus, import of..... 11 S
Pictou county, N.S., production of coal..... 31 S
Pigments, imports..... 11, 81-83 S
production..... 82 S
Pike river, Atlin lake, B. C., magnesite examined .. 23 B
description.....57 A, 10 B
Pine, bull, Kootenay district, B.C.. ..... 101 A
Pine creek, Atlin district, B.C., note on..... 56 A
description of .....65 A, 10, 38 B
yellow gravels of..... 33 B
section at Discovery claim..... 40 B
placer mining..... 40 B
Pine lake, Rainy River district, O., rocks of..... 117 A
Pins, Rapide des, Lièvre river, Q., rocks at..... 56 J
Piscatosin river, Ottawa county, Q., description of..... 70 J
Plant collections from Yukon and Atlin, B.C..... 210 A
Plants, Canadian, Catalogue of, part VII prepared..... 210 A
of Sable Island..... 218 A
Plantagenet, O., borings at..... 11 G
Plantagenet township, O., Utica shale formation. ..... 88 J
Platinum, production..... 8, 136 S
export..... 10 S
import.....11, 137 S
Playfair iron mine, Dalhousie township, O., description of..... 70-74 I
plan and cross sections..... 70 I
Pleistocene fossils in the vicinity of Ottawa..... 51-55 G
plants..... 55, 56 G
Plumbago, export. ..... 10 S
Plumbob creek to Boundary line, B.C., character of rocks... 88 A
Plumweseep, Kings county, N.B., analysis of water... 56 R
Plutonic rocks, north of Ottawa.19, 20, 50 O

	PAGE.	
Pointe au Chêne, Argenteuil county, Q., rocks at	37	J
Calciferous formation	83	J
deposit of asbestus	107	J
Point Fortune, Vaudreuil county, Q., Calciferous formation near	83	J
Point Hills islands, James bay, N.E.T., gold and silver assay	41	R
Pokiok river, N.B., geology of	13	M
Ponsonby township, Ottawa county, Q., rocks in	38	J
note on roads	38	J
Pontiac county, geology of *See* Argenteuil.	1-143	J
Porphyrite from Great Bear lake, N.W.T., examined	33	C
Porphyrites of Atlin district, B.C.	28-30	B
Porphyry stuff, microscopic description of a	24	B
Porphyry from Camsell river, N.W.T., examined	31	C
Portland promontory, Hudson bay, gold and silver assay	40	R
Portland township, Frontenac county, O., occurrence of hæmatite	78	I
Portland township, Ottawa county, Q., west and east, mica mines in	133	J
Portland East township, Ottawa county, Q., rocks of	52	J
Portland West township, Ottawa county, Q., description of asbestus	105	J
Potsdam formation in the Ottawa valley	76, 79, 81	J
occurrence of fossils	76 G, 81	J
sandstone, north of the Ottawa	17	J
list of fossils	139	J
Pottery, production of	8, 130	S
Precious stones, production	8	S
import	11	S
Priest creek apatite mine, Denholm township, Q., rocks of	103, 114	J
Proudfoot township, Parry Sound district, O., occurrence of spessartite	25	R
Prouses tunnel, Atlin district, B.C., gold contents of gravel	32	B
Publications, issued	3	A
special exhibition	6	A
Pugh and Weart's graphite mine, Buckingham township, Q., rocks of	108	J
Pumice, import of	11, 16	S
Pyrite from Ottawa county, Q., examination of ore	37	R
Pyrites, production	8, 113	S
export	10	S
import	114	S
Pyroclastic rocks of Atlin district, B.C.	24	B
Pyroxene and calcite, Gatineau district, note on	103	J

	PAGE.	
Pyroxene, occurrence in Ottawa county, Q	52, 55, 96	J
colour of	95	J
relations with the gneiss	96, 104	J
occurrence of apatite in	67, 98	J
analysis of	28	O
Pyroxene mica, in Wentworth township, Q	23	J
Pyroxenites of plutonic origin	21	O
examples at Poupore post office.	22	O
of Upper Lièvre river	23	O
age of	23	O
never distinctly bedded	24	O
transition into gneiss	26	O
in apatite veins	27	O
secondary	46, 50	O
pure pyroxene aggregates	47	O
pyroxene-phlogopite aggregates	47	O
pyroxene-scapolite aggregates	49	O
transition of pyroxenite	51	O
Pyrrhotite from Hudson bay, N.E.T., examination of ore	37	R
from Renfrew county, O	37	R
from Texada island, B.C.	37	R
from Vancouver island, B.C.	38	R
Pytongo lake, Pontiac county, Q., description of	68	J
Quarries, limestone and dolomite, south of Ottawa, O., notes on	136	A
Quartz, production of	8, 137	S
import	138	S
occurrence north of Ottawa	38	O
replaced by intergrowth of feldspar and quartz	70	O
and lode mining in Atlin district, B.C.	44	B
veins, Yukon district	21, 22	A
Quartz creek, Yukon, description of	49	A
first discovery of gold	49	A
newberyite and struvite described and analysed	13, 14	R
Quartzite from Montebello, Q., composition of	7	O
from the Squaw Hill apatite mine	53	O
grit from Great Bear lake, examined	29	C
Quebec, work in	138	A
mineral production	8	S
production of copper	43	S
production of iron	53, 54	S
export of iron	55, 59	S
production of gold	102	S
Queen's county, N.B., list of striæ	24	M
Radenhurst iron mine, Lavant township, O., description of	52-54	I
Railway lines round Ottawa	6	G
elevation of stations	7-9	G
Railway route to Hudson Bay	115	A
Rainy River district, O., rocks of	116-121	A

	PAGE.
Ramsay's Corners, Gloucester township, O., borings near.	10 G
Ramsay township, Lanark county, O., analysis of water.....	58 R
Rat lake, Ottawa county, Q., rocks at.....	59, 65 J
Reculon portage, Gatineau river, Q., rocks at.....	69 J
Reed lake, Sask., garden at.....	114 A
Renfrew gold district, N.S., survey and description of...169,	170 A
section of auriferous vems.....	172 A
gold product.....	173 A
cause of the present stagnation	174 A
prospects for larger working ..	174 A
Rensselaerite found at Pointe au Chêne, Argenteuil county.	37 J
in Grenville township, Q.....	138 J
in Hull township, Q.....	138 J
Rey, Lac, Camsell river, N.W.T., description of.....	21 C
Richardson bay, Great Slave lake, note on.....	11 C
Richardson, James, report of....	8 J
Richmond gulf, Hudson bay, description and rocks 142,	143 A
gold and silver assay	39 R
Rideau river, near Ottawa, O., shales on the..... 32,	34 G
Rigaud mountain, south of the Ottawa, Q., geology of.. 7, 17,	83 J
boulder beach of.....	93 J
Rigaud village, Vaudreuil county, Q., rocks at.....	80, 81 J
Ritchie iron mine, South Sherbrooke township, description of.....	42 I
microscopic examination of rocks.....	89 I
River channels, post-glacial, of Atlin district.....	35 B
flats along St. John river, N.B.	33 M
Rivière à la Graisse, Vaudreuil county, Q., Calciferous formation near.....	83 J
Road making in N.B., materials for.....	162 A
Robertsville iron mine, Palmerston township, O., description of mine.....	29-32 I
sketch plan of mine.....	30 I
microscopic examination of rocks.....	90 I
Rocher Rouge, Great Bear lake, N.W.T., hematite examined.....	21 R
analysis of hematite.....	36 R
Rockliffe park, Ottawa, occurrence of Chazy shales.....	31 G
rifle range, Ottawa, formation of strata.....	10 G
Rock creek, Klondike river, N.W.T., clay examined.....	60 R
Rockland, Russell county, O., borings at.....	11 G
rocks at.....36, 80, 83,	86 J
Rogers, Lake, Camsell river, N.W.T., description of.....	22 C
Roofing cement, statistics.....	8 S
Rosamond, Lake, Camsell river, N.W.T., description of....	23 C
Rossland, B.C., progress of.....	86 A
Ross Mountain mine, Lièvre river, Q., rocks of.....	96 J
Rossport, Thunder Bay district, O., gold and silver assay..	42 R
Ross quarry, township of East Hawkesbury, O., note on building stone.....	136 J
Ross township, Renfrew county, O., analysis of dolomite...	35 R
Rouge, Cape, Inverness county, N.S., hematite examined..	62 R
Rouge and Nation rivers, geology of the area between.....	32-46 J
colonization roads.....	32 J
Rouge and North rivers, geology of the district between....	17-32 J
Rouge lake, Ottawa county, Q., rocks at.....	59 J
Rouge river, Q., character of county along.....	10 J
description of river and tributaries.....	29-32 J
Round lake, Addington township, Q., rocks at.....	38 J
Round lake, Pontiac county, Q., rocks of.....	68 J
Ruby creek, Atlin district, B.C., description.....62A,	41 B
Rupert river, Hudson bay, description of coast.....	146 A
Russell township, O., borings in.	11 G
Lorraine formation.....	19 G
Chazy limestone.....	31 G
Russia, exports to.....	10 S
Sable island, N.S., its appearance	212 A
wind and sea action	213 A
sand deposits.....	213 A
decreasing in size.....	213 A
lagoon and sand-hills.....	214 A
old level of the island.....	215 A
fresh-water ponds.....	215 A
origin of cranberry beds.....	216 A
climate and crops grown.....216,	217 A
flora of sand-hills.....	218 A
birds and fishes.....	219 A
Sable, Lac au, Ottawa county, Q., rocks at.....	43 J
Sables, Lac des, Lièvre river, Q., rocks at.....	56 J
Saint-Cyr, A., specimens of rocks collected by.....	31 B
Salmon river, Ottawa county, Q., rocks at	37 J
Salt, production... .....7, 8, 9,	115 S
export..... 10,	115 S
import..... 11,	116 S
Salt brook, Tobique river, N.B., analysis of water	50-52 R
Saltpetre, import of.....	11 S
Sand deposits near the Rideau, O.	12 G
on Sable Island	213 A
Sands and gravels, production...	8 S
import.....	11 S

PAGE.

Sands and gravels, export..... 131 S
Sandstones and conglomerates of Atlin district, B.C..... 23-26 B
Sandy Hill, Ottawa, area of Utica shale..... 23 G
Sapphire, probability of, in Ontario..... 131 A
Sarahk, Lake, Camsell river, N. W. T. description of..... 23 C
Saskatchewan district, work in.. 110 A
Saskatchewan river, delta plain of..... 114 A
Saxicava rugosa found near Cantley and McGregor lake, Q. 92 J
Scapolite at contact of graphitc veins, Graphite City, Q... 73 O
crystals, analysis of..... 37 O
Scapolite gabbros examined microscopically..... 21 O
from the Vavasour mine..... 50 O
Scaumenac river, N.B., occurrence of copper ..... 149 A
Schistose rocks near Perry creek, B.C..... 93 A
along St. Mary river, B.C..... 97 A
Schists, crystalline, West Kootenay, B.C..... 83 A
Schorlomite from Ice river, Rocky mountains, B.C., description and analysis..... 12, 13 R
Scott mica mine, Old Chelsea, Q., note on..... 39 G
rocks of..... 124 J
Sections, stream-gravels, Bonanza Creek..... 23 A
of Bonanza Valley ..... 25 A
of Glacier inlet, Atlin district, B.C..... 29 B
stream gravel on Willow creek, B.C..... 36 B
Pine creek gravels, B.C..... 39 B
Sedimentary rocks, West Kootenay, B.C..... 84 A
Selwyn, Dr., views of, on anorthosites..... 12 J
quoted on the origin of apatite. 15 O
Selwyn lake, Rainy River district, O., description and rocks..... 116 A
Sericite from Yukon district, note on..... 24 R
Serpent lake and creek, Ottawa county, Q., rocks at..... 48 J
Serpentine, in Atlin district, B.C., note on..... 22 B
in Hull township, Q..... 40 G
Serpentine river, N.B., description of..... 150 A
gold-bearing gravels..... 150 A
Seven Islands, Bay of, Saguenay county, N.B., analysis of water..... 52, 53 R
Sewer pipe, production..... 8, 129 S
Seybold's mica mine, Wakefield township, Q..... 118 J
Shale, examinations of..... 63, 64 R
See Utica shale.
Sharp point, Vancouver island, B.C., analysis of water.... 55, 56 R

PAGE.

Sheen township, Pontiac county, Q., magnctite examined... 63 R
Sheep Lake plateau, B.C., description of..... 80 A
Shefford mountain, Q., rocks and height..... 138 A
Shell marl of Hemlock lake, analysis of..... 47 G
in Argenteuil county, Q..... 137 J
Sheogomoc lake, N.B., note on.. 15 M
Shikag lake, Rainy River district, O., description and rocks..... 117 A
Shonkinite from the Crown Hill mine, Lièvre river, Q..... 44 O
microscopic description..... 44 O
analysis of..... 45 O
Shore-lines on Great Bear lake... 28 C
Siderite found at Great Bear lake..... 27 C
Silurian area, fertility of, N.B... 154 A
fossils in New Brunswick, discovery of..... 160 A
limestones in New Brunswick. 36 M
Silver, production. .....7, 8, 9, 108-112 S
export.....10, 112 S
native, Thunder Bay district, O., note on..... 24 R
Silver, L. P., work by..... 148 A, 6 M
Silver Lake iron mine, South Sherbrooke township, O., description of ..... 41 I
Simon, Lac, Ottawa county, Q., rocks on..... 40 J
country north of..... 41 J
Six Portages, Ottawa county, Q., rocks at..... 64 J
Sixteen Island lake, Argenteuil county, Q., limestones of.. 22, 24 J
deposits of asbestus..... 107 J
Skiff lake, N.B.. note on..... 15 M
Slate, production..... 8, 120 S
import..... 11, 120 S
export ..... 121 S
belt in New Brunswick, investigation of age of..... 160 A
Sloco inlet, B.C., note on. ... 57 A
Sloco lake, Atlin district, B.C., note on..... 8 B
Small Otter river, O., rocks of... 121 A
Smith bay, Great Bear lake, note on..... 12 C
Snow's mine, Hull township, Q., note on mica..... 41 G
Soaptone, production of..... 8, 138 S
Solomon Temple islands, James bay, N.E.T., gold and silver assay..... 39 R
South Burgess, O., analysis of phlogopite..... 30 O
South Canonto, Frontenac county, O., graphite examined. 62 R
South Crosby township, Leeds county, O., mines of..... 66, 67 I
occurrence of hæmatite..... 79 I
South March, O., gabbro from... 43 O
South Sherbrooke township, Lanark county, O., description of mines..... 32-44 I

	PAGE.
South Uniacke gold district, N.S., description of	180 A
South-west Miramichi river, N.B., geology of	12 M
agricultural capabilities of	35 M
Spanish West Indies, exports to	10 S
Spectacle lake, Argenteuil county, Q., limestones of	22 J
Specular iron from Great Bear lake, N.W.T., note on	21 R
from Yukon district	21 R
Lewis river, examination of	64 R
Spelter, import of	11, 142 S
Spessartite from Parry Sound district, O., note on	25 R
Sphalerite from township of Bouchette, Ottawa county, Q., note on	25 R
Spodumene from James bay, N. E.T., description of	15 R
Springhill coal field, N.S., borings at	163 A
note on Mr. Barlow's general section	166 A
comparison of results	167 A
Sponges, determination of	205 A
Spruce creek, Atlin district, B.C., yellow gravels of	32 B
description of	64 A, 40 B
placer mining	41 B
Spruce in the Yukon district	18 A
Squaw Hill apatite mine, Lièvre river, Q., rocks of	102 J
St. André Avelin, Ottawa county, Q., rocks at	39 J
St. Andrews mountain, Q., note on	80 J
St. Andrews, Q., boulder ridges, east of	90 J
Ste. Angélique range, augmentation of Mille Isles, Q., distribution of rocks	19 J
St. Antoine mica mine, Wright township, Q., note on the mica	66 J
description of rock	127 J
note on work done	134 J
Ste. Croix, Lac, Camsell river, N.W.T., description of	21 C
St. Germain lakes, Wakefield township, Q., note on	75 J
St. Grégoire, Nicolet county, Q., analysis of water	53-55 R
St. Jean, Wentworth township, Q., limestones of	22 J
St John river, N.B.	8-11 M
river tides and falls	9 M
non-tidal oscillations	10 M
inclination in the tidal portion	10 M
hydrographic depression	11 M
St. John valley, N.B., deposits of	148, 149 A
vegetation of	211 A
indifferent farming	211 A
St. Jovite, DeSalaberry township, Q., rocks at	26, 28, 30 J
St. Liboire, Bagot county, Q., carbonaceous shale examined	64 R
St. Mary lake, B.C., rocks around	96 A
St. Mary river, B.C., description of	94 A
St. Paul l'Ermite, L'Assomption county, Q., analysis of water	57 R
St. Pierre, exports to	10 S
St. Pierre, Côte, Nation river, Q., rocks at	39 J
deposit of asbestus	106 J
Ste. Rose, Laval county, Q., analysis of water	57, 58 R
St. Sauveur, Q., limestone of	20 J
Stafford township, Renfrew county, O., occurrence of marl	23 R
marl examined	63 R
Stag lake (lac du Cerf), Ottawa county, Q., rocks at	49 J
Stairs, Lake, Camsell river, N. W.T., description of	20 C
Stanley, N.B., occurrence of gold	41 M
Star Hill apatite mine, Lièvre river, Q., rocks of	99 J
Stephen dyke, Atlin district, B. C., description	38 B
Stewart river, Yukon river, gold and silver assay	45 R
Stibnite from Yukon district, note on	25 R
Stony beach, Assiniboia, gold and silver assay	46 R
Stony Indian reserve, Al., analysis of coal	30 R
Storrington township, Frontenac county, O., occurrence of hæmatite	76-78 I
Striæ, glacial, in the vicinity of Ottawa	18 G
in New Brunswick	17-26 M
Striation, Atlin district, B.C.	73 A
New Brunswick	17 M
Strontianite occurrence in Nepean township, O	44 G
analysis	44 G
Struvite from Yukon district, where found, description and analysis	13, 14 R
Sturgeon lake, Rainy River district, O., rocks of	118 A
depth of	119 A
Sucker river, Atlin district, B.C., description of	9 B
Sucreries, Lac des, Ottawa county, Q., rocks at	43 J
Sugar Bush lake, Ottawa county, Q., rocks at	45 J
Sugarwood brook, N.S., rocks on	165 A
Sullivan gold mine, near Kimberly, B.C., note on	96 A
Sulphate of copper, import of	11 S
Sulphur, import of	11 S
Sulphur creek, Yukon, character of valley	45 A
bed-rock and gravels	46 A
gold contents of gravels	47 A
Sunbury county, N.B., list of striæ	23 M
occurrence of bog-iron ore	40 M
Sunset mountains, B.C., ores of	70 A

	PAGE.
Surprise mountain, B.C., quartz veins of	69 A
Syenite gneiss, intrusive nature of Grenville township, Q.	80 O
Syenite of Grenville and Chatham, Q.	14 J
Synclinal structures in limestones, Grenville, Q.	23 J
Tagish Houses, B.C. note on hay meadows	57 A
Takaatcho river, Great Bear lake	16 C
Taku Arm, B.C., description of..	53, 54 A
Taku Inlet, B.C., note on	54 A
Taku mountain, Atlin district, B.C., description	28 B
Taku river, Atlin district, B.C., description of	9 B
Taku trail, B.C., description of..	61 A
Tamworth, Addington county, O., occurrence of hæmatite	80 I
Tapanee lake, Q., description	71 J
Tapanee river, Lièvre river, Q., description and rocks	71 J
Tasiagaluk lake, description of..	141 A
country and rocks	141 A
Telluride from Nigger creek, B. C., examined	92 A
Templeton, Q., limestone at	33 G
Potsdam sandstsne	81 J
Templeton township, Ottawa county, Q., description of asbestus	105, 106 J
list of mica mines	129, 131 J
Tenika-Dawaso-necka lake, N.W. T., description of	23 C
Terraces of Atlin district, B.C., composition of	11 B
height of	11 B
terraced valleys	14 B
in Ottawa county, Q.	56 J
along the Rouge and Lièvre rivers	91 J
in St. John valley, N.B.	149 A, 31 M
in New Brunswick	29-31 M
how formed	30 M
Terra-cotta, production	8, 129 S
Terror, Lake, Portland West township, Q., deposit of graphite	109 J
Tertiary rocks, Yukon district..	20 A
Gold creek, B.C.	89 A
Teslin lake, B.C., journey to.	60 A
rocks noted	61 A
Tetradium fibratum in Black river limestone, Hawkesbury, O	87 J
Tétreauville, Hull, Q., limestones of	27 G
Texada island, B.C., pyrrhotite examined	38 R
Thirty-one Mile lake, Ottawa county, Q., rocks at	62 J
Three Mountains lake, Ottawa county, Q., limestones of..	30 J
Thron gulch, Atlin district, B.C., geology of	37 B
Thurso, Ottawa county, Q., rocks in vicinity of	51 J
Tiles, statistics	8 S
Tilsonburg, Oxford county, O., analysis of water	58, 59 R
Timber, Kootenay district, B.C.	101 A
Atlin district, B.C.	12 B
New Brunswick	38 M
Tin and tinware, imports of	139 S
import of tins	11 S
Tin, oxide of, in mica rocks	72 O
Titanite, occurrence of, north of Ottawa	38 O
description of	76 O
Tobique river, N.B., alluvial gold of	150 A
geology of	12 M
analysis of water	48-50 R
Toochi river, B.C., description of	53, 54 A
Too Much Gold creek, Yukon, note on	51 A
Torrence, J. F., quoted on the occurrence of apatite	13 O
Tourmaline in Ottawa county, Q., note on	37 O
Tracy creek, B.C., rocks of..	100 A
Tree limit on the coast of Hudson Bay	140, 141 A
Trees, Yukon district	18 A
Kootenay district	102 A
of economic importance, N.B..	38 M
Trembling lake, Q., rocks at	26 J
Trembling mountain, Q., description of	27 J
examination of gneiss	10 O
Trenton basin in township of Russell, O	134 A
Trenton limestone, foot of Parliament Hill, Ottawa, photo of	22 G
in the vicinity of Ottawa	24-26 G
list of fossils	61-68 G
in the valley of the Ottawa	87 J
undulations in the strata	87 J
relation to the Utica shale..	87 J
anticlines and faults	88 J
list of fossils	141-143 J
Tripolite, production of	8, 139 S
Trout lake, Ottawa county, Q., rocks of	34 J
Tudor, township of, O., rocks of.	124 A
Tulameen river, Yale district, B.C., magnetite examined.	63 R
Two Mountains, Lake of, Q., rocks of	80 J
United States, exports to	10 S
Upper Newport gold district, N.S., description of	181 A
Uranophane from township of Villeneuve, Ottawa county, Q., description of	16 R
Utica shale in vicinity of Ottawa	21-24 G
thickness and extent	21 G
exposures near Ottawa	22 G
photograph of	22 G
in contact with Trenton limestone	22, 23 G

	PAGE.
Utica shale used for making streets	47 G
list of fossils	58-60 G
outlier at Maxville, O.	135 A
in the basin of the Ottawa	88-90 J
character and thickness	89 J
Vankleek Hill, Prescott county, O., rocks near	85 J
boulders near	90 J
Vavasour apatite mine, Ottawa county, Q.	17-26 O
Veinstone, figure of, showing layers of apatite and pyroxene, Vavasour mine	24 O
Vennor, H. G., work of	6 J
exploration by	9 J
quoted	13 J
Venosta mica mine, Low township, Q., note on	127 J
Vert, Lac, to Lac des Sucreries, Ottawa county, Q., note on rocks	38 J
Victoria, Alta., borings for petroleum	11 A
comparison of sections	12 A
report on bore-hole	14 A
equivalency of Cretaceous rocks	14 A
Victoria county, N.B., arable lands of	154 A
list of striæ	26 M
Victoria lake, Ottawa county Q., rocks at	65 J
Villeneuve mine, Villeneuve township, Q., rocks of	112 J
deposit of felspar	135 J
Villeneuve township, Ottawa county, O., uranophane examined	16 R
monazite examined	24 R
Volcanic rocks, Kootenay district, B.C.	101 A
Wahnapitae, Lake, Nipissing district, O., gold and silver assay	42 R
Wait, F. G., work by	191 A, 1-64 R
Wakefield cave, Ottawa county, Q., situation of	74 J
Wakefield lake mica mines, Portland West township, Q.	120 J
Wakefield, Ottawa county, Q., rocks in the vicinity of	67 J
apatite deposits at	104 J
Wakefield township, Ottawa county, Q., geology of	72-76 S
mica mines in	132 J
Walker graphite mine, Buckingham township, Q., rocks of	108 J
note on the workings of	67 O
Wallbridge iron mine, Eldorado, O., note on	129 A
Wallingford mica mine, Templeton township, Q.	129 J
Walrus island, James bay, N.E. T., danalite examined	15 R
spodumene examined	15 R
epidote examined	20 R
Wardner, B.C., character of rocks	88 A
War Eagle mine, Rossland, B.C., gmelinite examined	21 R
Water analysis of Atlin district, B. C.	46, 47 B
Waters, natural, analyses of	48-60 R
Weart's graphite mine, Buckingham, Q.	108 J
Webster mica mine, Hull township, Q.	121 J
Wentworth township, Q., limestones of	22 J
deposits of marl	
West-end mine, Thunder Bay district, O., occurrence of native silver	137 J, 24 R
Westborough, near Ottawa, O., Chazy limestones and shales	30, 32 G
West Kootenay, B.C., work in	75-86 A
area of map-sheet	75 A
topographical features	77 A
timber	80 A
geology	81 A
general progress	86 A
White, Dr. D., opinion of, on the relations of Carboniferons and Devonian rocks of N. S., and N.B	202 A
White, James, survey by	9 J
White Eagle fall, Camsell river, N.W.T., note on	19 C
Whitefish lake, Ottawa county, Q., rocks at	60, 61 J
mica mine of	60, 114 J
White Horse copper-belt, Lewes river, N.W.T., grossularite described and analysed	14, 15 R
allophane examined	18 R
chrysocolla examined	19 R
erythrite examined	20 R
hematite examined	22 R
occurrence of magnetite	23 R
occurrence of stibnite	25 R
occurrence of wilsonite	25 R
specular iron examined	64 R
Whiteaves, Dr. J. F., work by	198 A
Whiting, production	8 S
import	11, 140 S
Wilbur iron mine, Lavant township, O., description of	46-52 I
sketch plan of mine	46 I
magnetic readings	50 I
general observations	51 I
history and shipments	52 I
characteristics of ore	52 I
microscopic examination of rocks	91 I
Wigwaskwa lake, Rainy River district, O., rocks of	117 A
Wild Horse creek, Kootenay river, B.C., description of	99 A
note on gold mining	99 A
rocks of	99, 100 A
Wilbur iron mine, Lavant township, O.	46 I

	PAGE.	
Williams iron mine, Bagot township, O., description of	64-66	I
sketch plan of	64	I
microscopic examination of rocks	81	I
Willimott, C. W., work by	196, 197	A
Willow creek, Atlin district, B.C., rocks of	66	A
section of stream gravel	36, 37	B
Willow river, Mackenzie river, exploration of	6	C
description of country	6	C
Wilson mica mine, Hull township, Q	122	J
Wilson iron mine, Bagot township, O., description of	61	I
Wilsonite from Yukon district, N.W.T., note on	25	R
Wilson, W. J., work by	6 M, 148	A
quoted	35, 38	M
Wilsons corner, Gatineau river, Q., mica mines at	116	J
Winchester, O., quarries near	136	A
Windsor series, fossils of the, in Nova Scotia	200	A
Wollaston, township of, O., rocks of	123	A
Wollastonite in graphite veins, Grenville, Q	75	O
Wolstenholme, Cape, Hudson bay, gold and silver assay	40	R
Woodward, Dr. A. Smith, on fish remains	203	A
Woodward, Dr. H., quoted	202	A
Wright creek, Atlin district, B.C., description of	64	A
gold found in biotite slates	43	B
Wright's mica mine, Hull township, Q	125	J
Wright township, Q., occurrence of mica	66, 134	J
Yahk river, B.C., character of rocks	89, 90	A
Yellow Knife bay, Great Slave lake, N.W.T., gold and silver assay	42	R
York county, N.B., list of striæ	17-23	M
occurrence of antimony	40	M
Yuill iron mine, Darling township, Lanark connty, O., description of	54	I
sketch plan of the mine	54	I
microscopic examination of rocks	91	I
Yukon district, work in	16-52	A
geography of Klondike region	16	A
topography	16-18	A
geology	18-26	A
gold in gravels	27, 28	A
methods of working	18-30	A
description of creeks	30-52	A
production of gold	105	S
Yukon river, N.W.T., gold and silver assay	46	R
Zigzag lake, Ottawa county, Q., rocks at	44	J
Zinc, production	8, 141	S
import	11, 141, 142	S
Zircon described	76, 77	O
Zoological work	198	A
collection, additions to	206, 208	A